Paruzzi Magazine

Digital Publication for the classic Volkswagen

06

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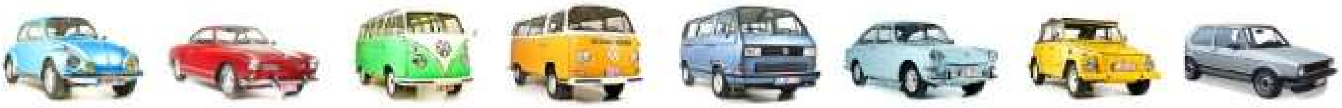

Paruzzi Magazine

VW Workshop Manuals

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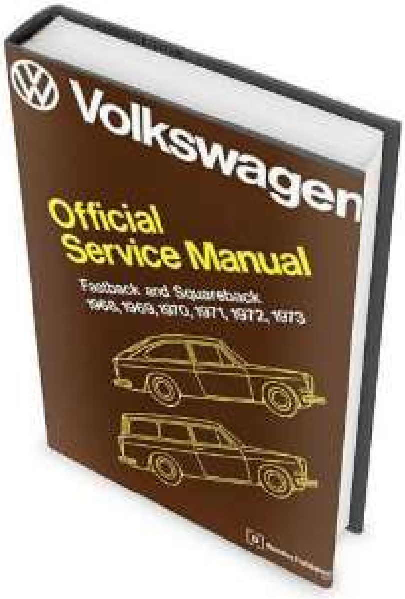

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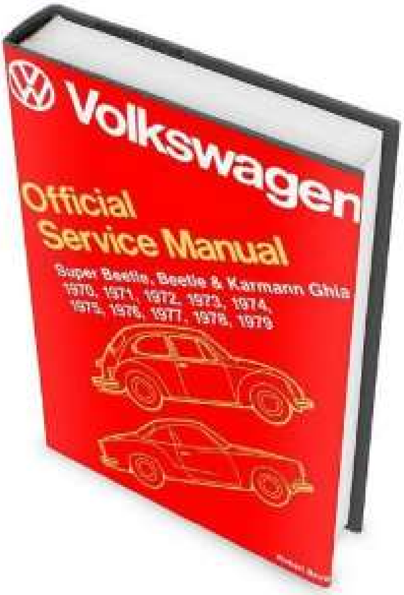
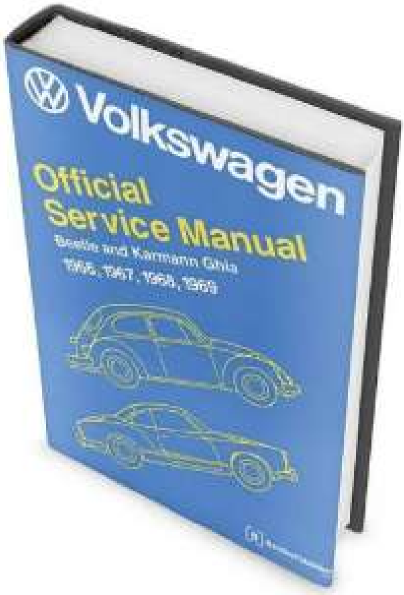


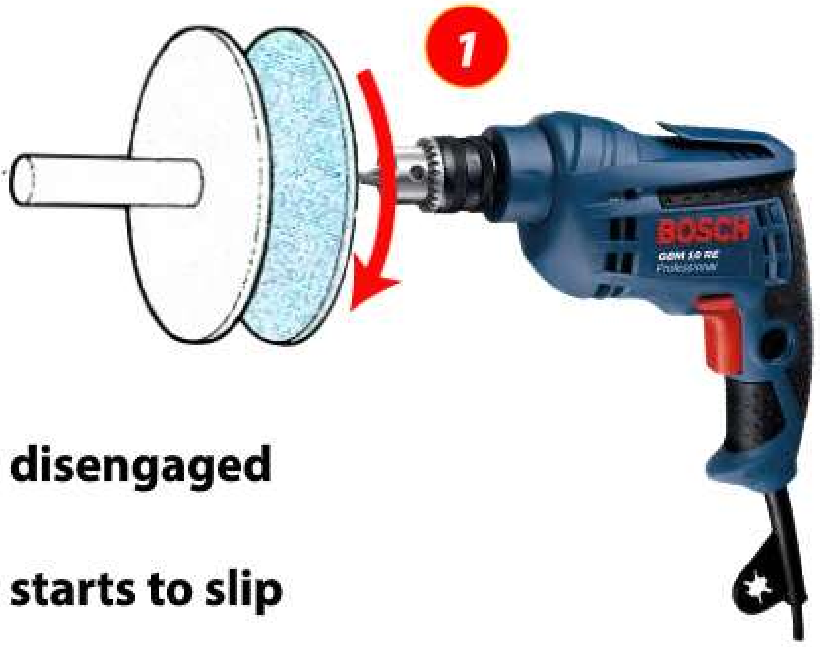


#16 Engine

The principal

I was really fascinated about the way our VW Fastback was working, the clutch was like a little miracle to me, I was only six at the time. Our Type 3 Volkswagen stopped when my father pressed the clutch pedal and it drove away when he released the pedal. If you understand how disc brakes work, you will have no problem understanding how the clutch operates.

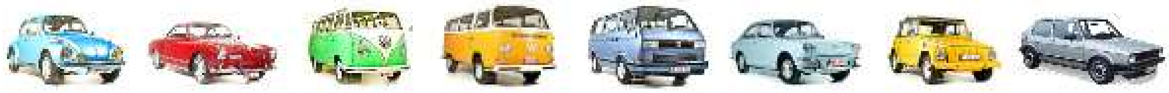
The clutch mechanism uses the same physics principal as disc brakes, friction between a metal disc and a friction plate. Image two sanding discs, one mounted on a electric drill and the other mounted on a shaft (1). The electric drill represents the VW engine and the shaft represents the drive shaft from the gear box.



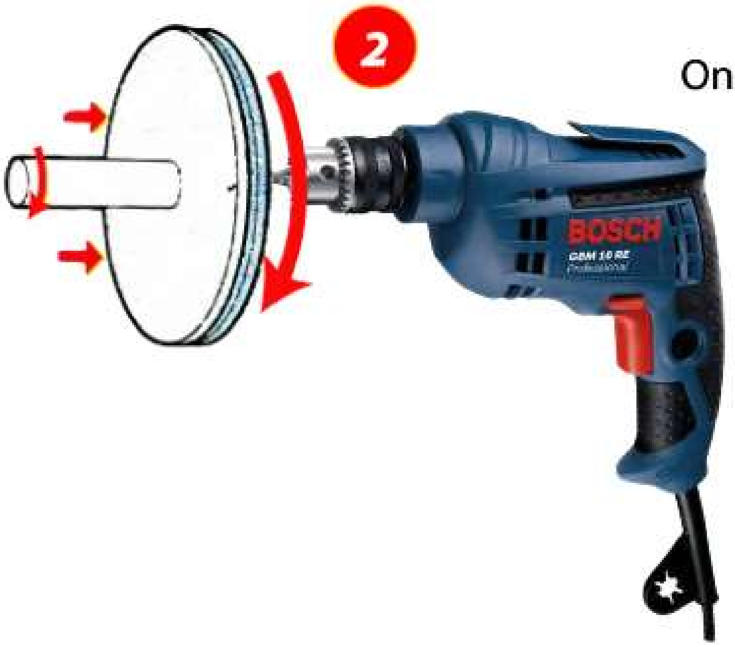
① **clutch disengaged**

② **clutch starts to slip**

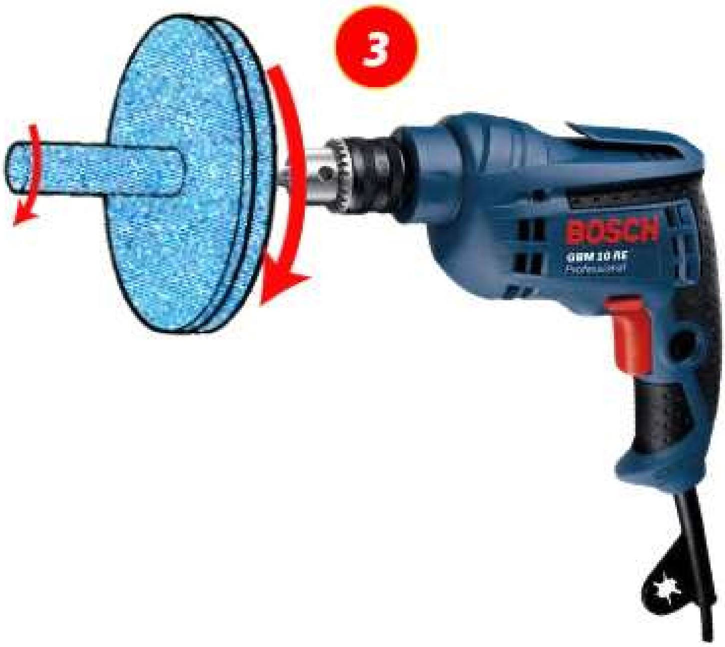
③ **clutch engaged**



the clutch concept



Once the rotating disc on the drill touches the disc mounted on the shaft (2), the latter will slowly start to rotate, it will slip and try to catch up with the speed of the drill. The more pressure between both discs, the faster the disc on the shaft will rotate until it reaches the same speed as the drill (3).



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#16

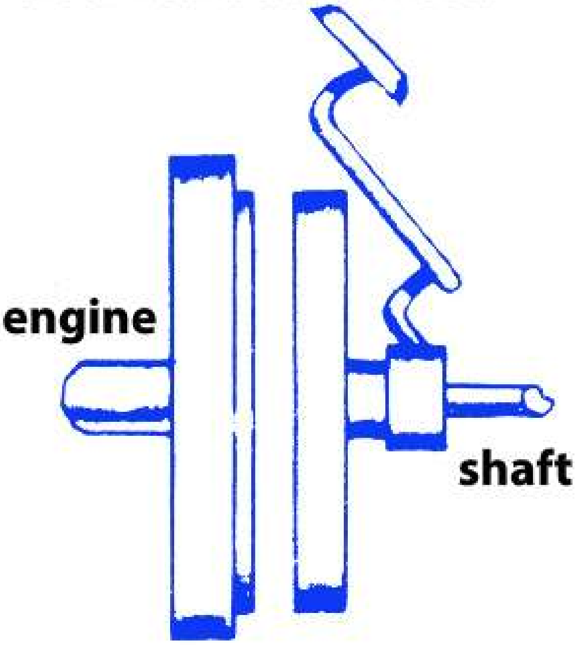
Engine

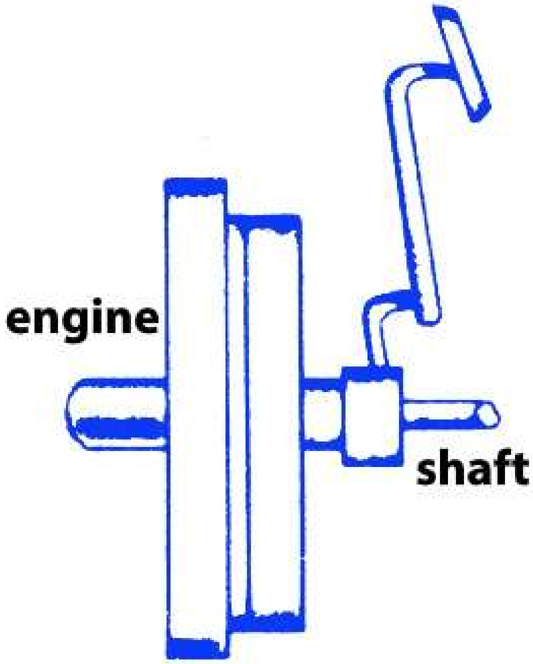
How it works

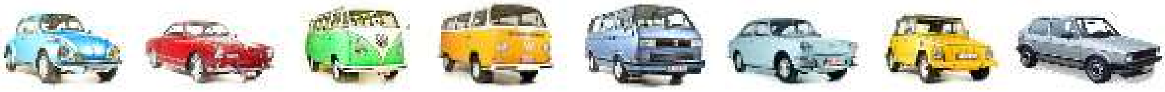
We will now try to be more concrete but still try to simplify so the explanation is still understandable. The drawings on this page originate from old school books, they also helped me to understand the basics. Below we show the basic mechanical principle of the clutch assembly. The clutch pedal works as a lever and pushes a friction plate against the flywheel, the rotating flywheel activates the friction plate, the shaft is connected to the gear box and ultimately to the drive shaft and wheels.

This is a very simplified view of course. The clutch assembly is a little more complex and it contains more parts than shown on the drawing below. We show a more representative drawing of a clutch assembly on the right.

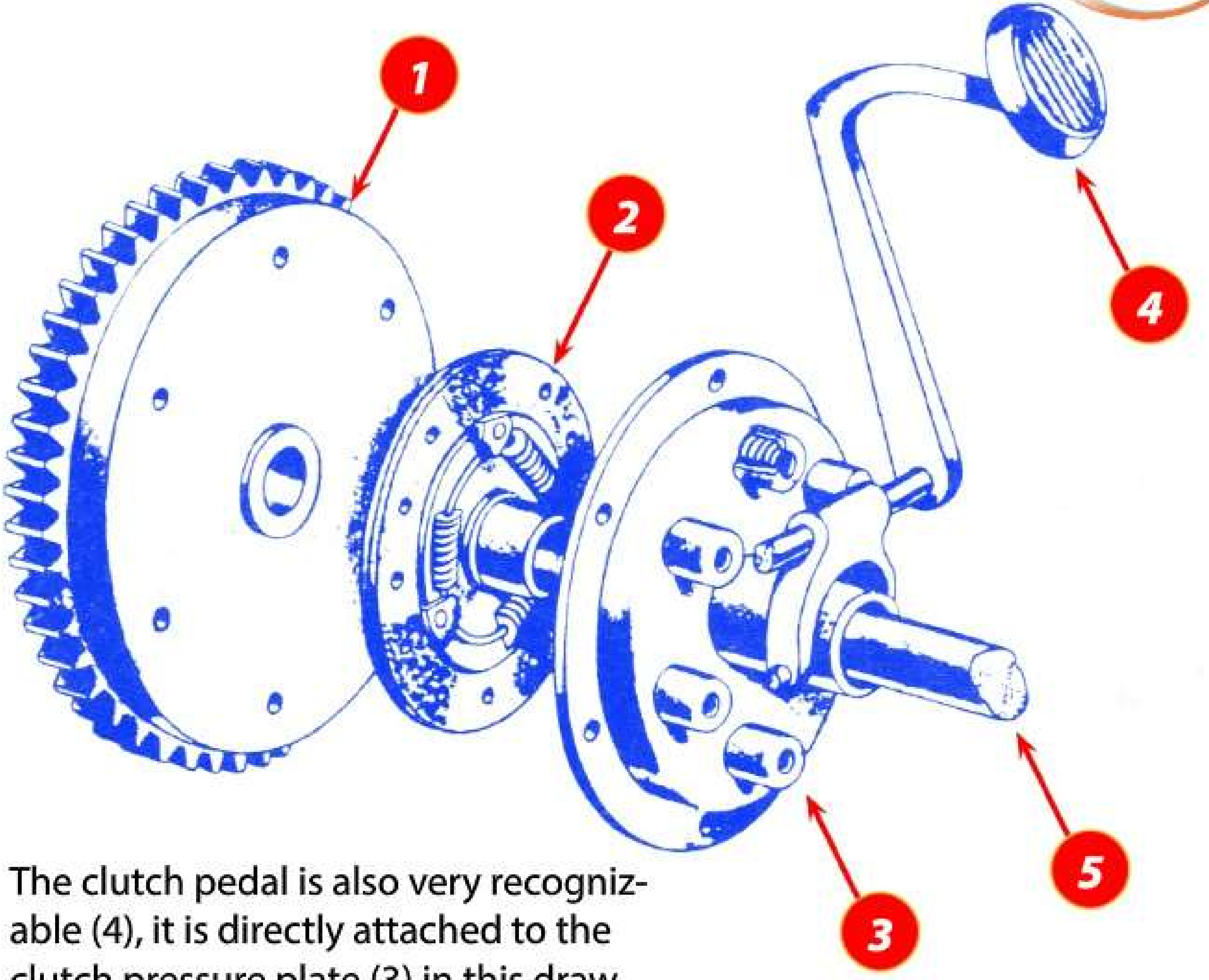
You will recognize the flywheel (1) on the left side. The flywheel is attached to the crankshaft, it transforms the movements of the pistons into a rotating movement to drive the gear box shaft.







the clutch concept



The clutch pedal is also very recognizable (4), it is directly attached to the clutch pressure plate (3) in this drawing (a metal cable connected to the clutch pedal operates the clutch pressure plate in our air-cooled Volkswagen). The clutch disc (2) is installed in between the flywheel and the pressure plate. This clutch disc will be pressured against the flywheel when the clutch pedal is released (clutch engaged), at this point the rotating movement of the flywheel will rotate the gear box shaft (5).

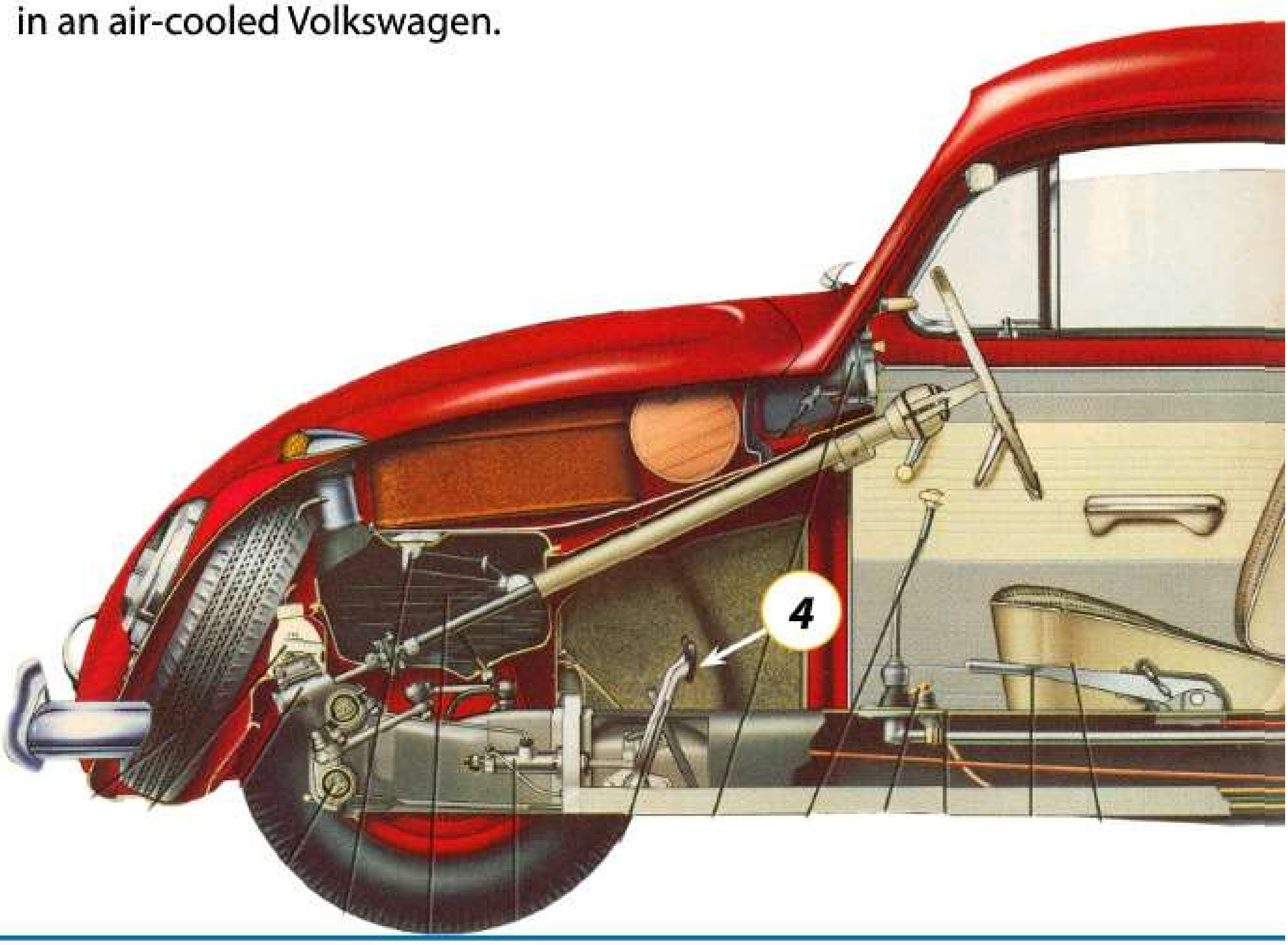
1	**flywheel**
2	**clutch disc**
3	**pressure plate**
4	**pedal**
5	**gear box shaft**

#16 Engine

Where is my clutch?

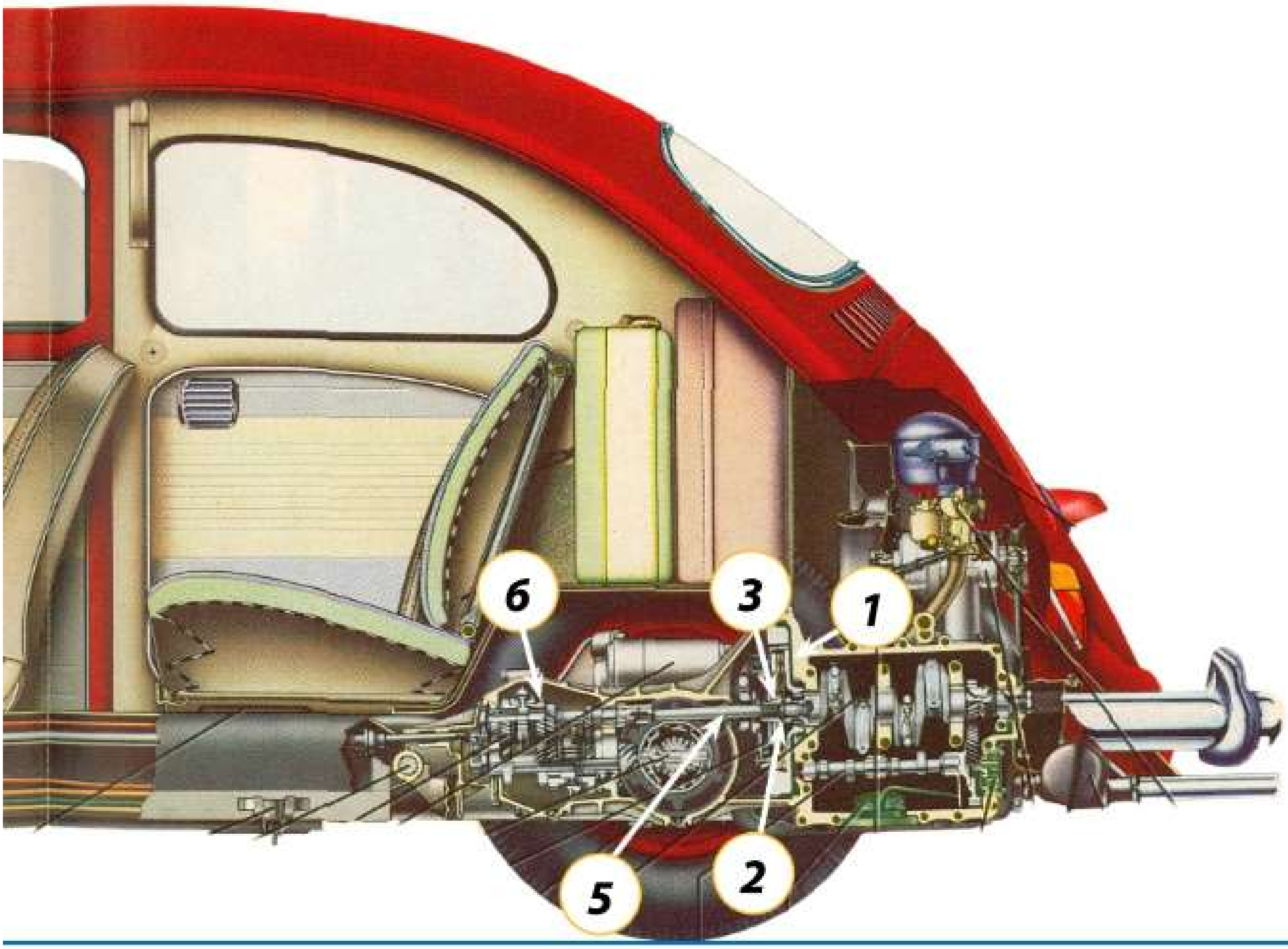
We know by now that the clutch assembly is located somewhere close to the flywheel and the gear box. The users manual of my 1960 VW 1200 includes this great drawing. I admire the graphical designers that used to draw these pages for Volkswagen. I like to use this drawing to explain where parts are located in an air-cooled Volkswagen.

To see the clutch assembly of your Volkswagen in real life you need to remove the engine. The clutch assembly is attached to the flywheel using bolts. It is very easy to work on the clutch once the engine has been removed.



the clutch concept

1 **flywheel**
2 **clutch disc**
3 **pressure plate**
4 **clutch pedal**
5 **gear box shaft**
5 **gear box**

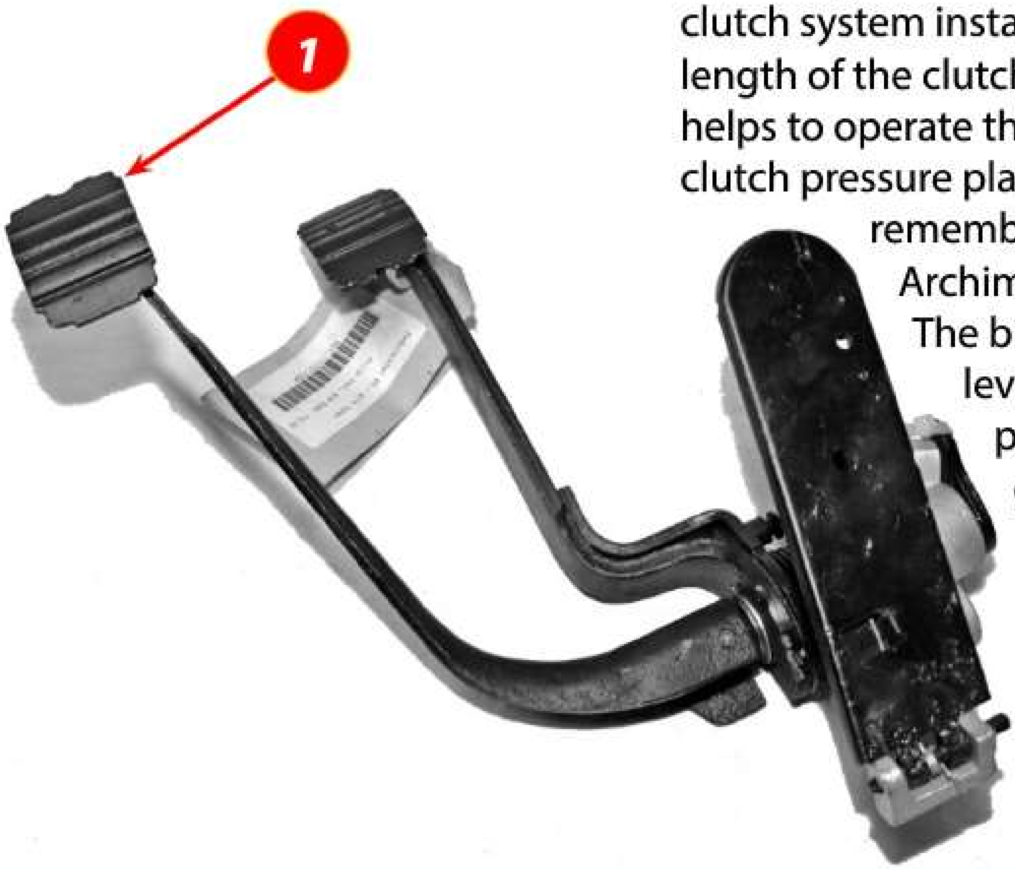


#16 Engine

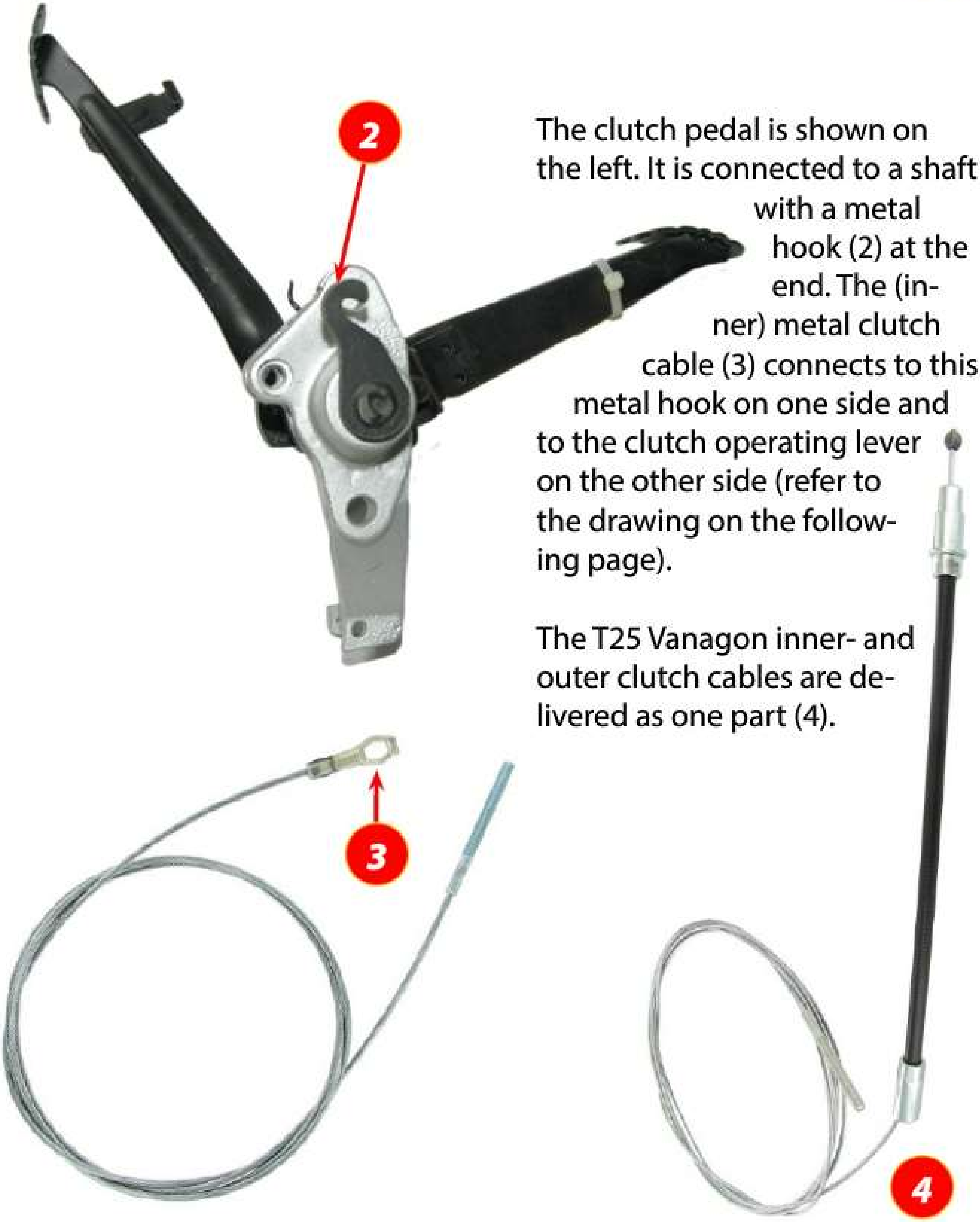
Clutch assembly parts

It all starts with the clutch pedal, it works like a lever to engage and disengage the clutch disc to and from the flywheel. This is the leftmost pedal (1) under the dashboard, next to the brake pedal. This clutch pedal is not installed if you drive an automatic or semi-automatic gear box Volkswagen, of course.

The clutch pedal is very tall, the tallest of all pedals. The newer cars have an hydraulic clutch assembly installed which makes it easier to operate the clutch pedal. But our Vintage Volkswagen didn't have that, the clutch system is operated by a metal cable without any help from a modern hydraulic system. The T25 Vanagon was the first Volkswagen with an hydraulic clutch system installed. The length of the clutch pedal helps to operate the strong clutch pressure plate, do you remember the law Archimedes law? The bigger the lever the more power you can generate.



the clutch concept

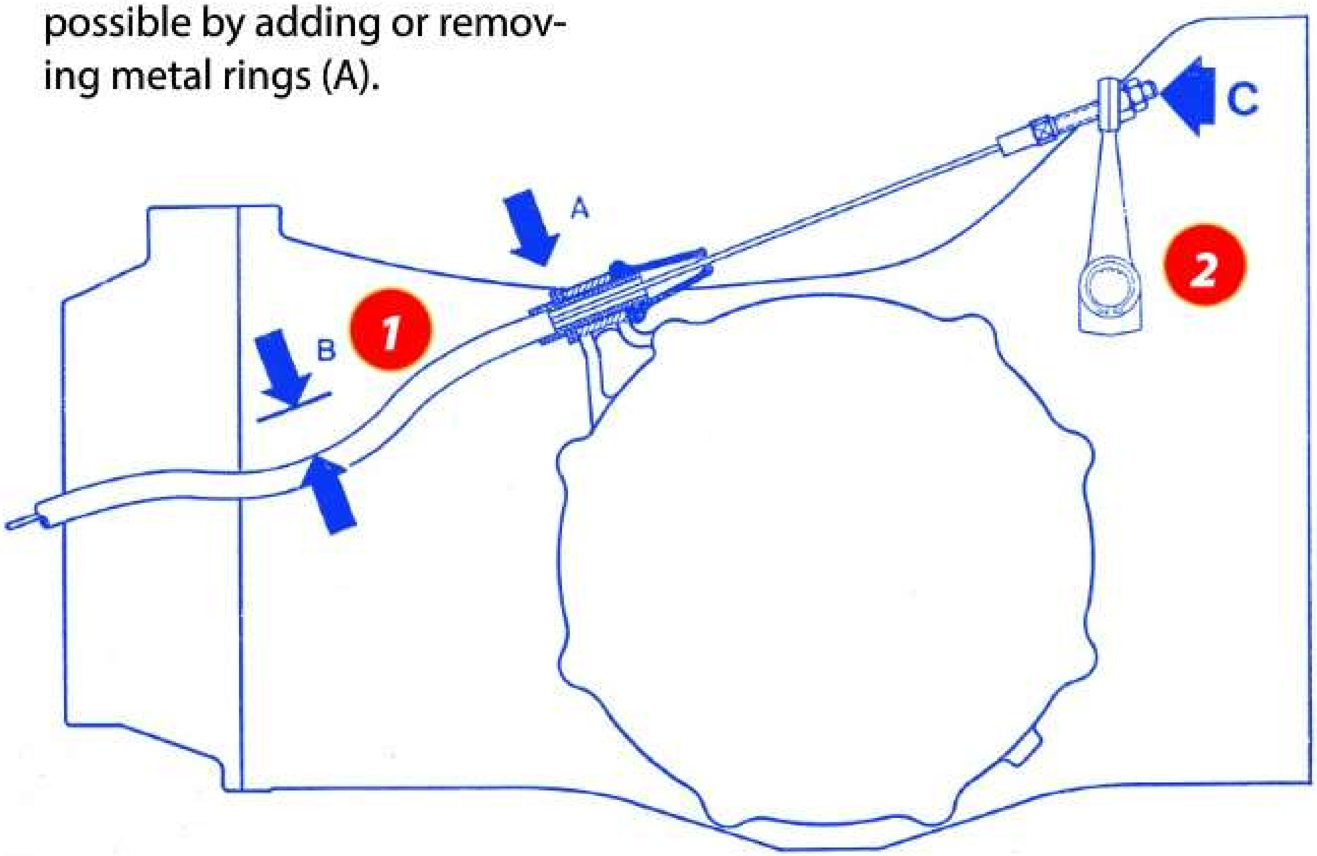


The clutch pedal is shown on the left. It is connected to a shaft with a metal hook (2) at the end. The (inner) metal clutch cable (3) connects to this metal hook on one side and to the clutch operating lever on the other side (refer to the drawing on the following page).

The T25 Vanagon inner- and outer clutch cables are delivered as one part (4).

#16 Engine

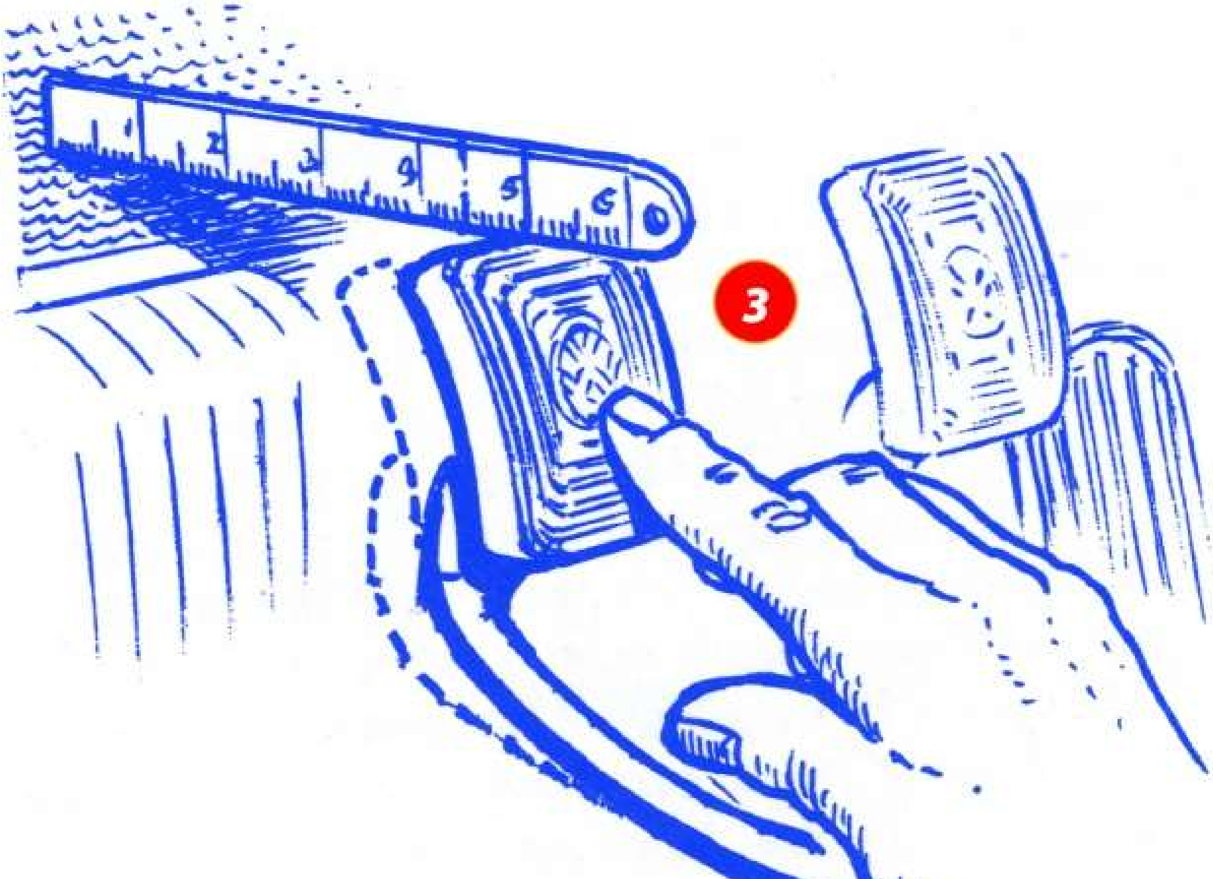
A short outer clutch cable (1) is used on the side of the clutch operating lever and the gear box (2), this outer cable needs to bend a little to allow the gear box to move while driving. The bend distance (B) needs to be between 25 mm and 45 mm (to be confirmed by the users manual of your Volkswagen). Adapting this bend distance is possible by adding or removing metal rings (A).



Clutch pedal free play

You need to fine-tune the clutch pedal so that there is some free play, this free play will avoid that the clutch operating lever is always under pressure and that the clutch disc starts to slip. The free play makes sure that there is a little slack between the clutch disc and the clutch release bearing (read more about this later).

You can adjust the clutch pedal free play (3) by adjusting the (butterfly) nut (C) located at the end of the clutch cable. We won't discuss the installation or dismantling of the clutch assembly in this article, we keep this for another edition.

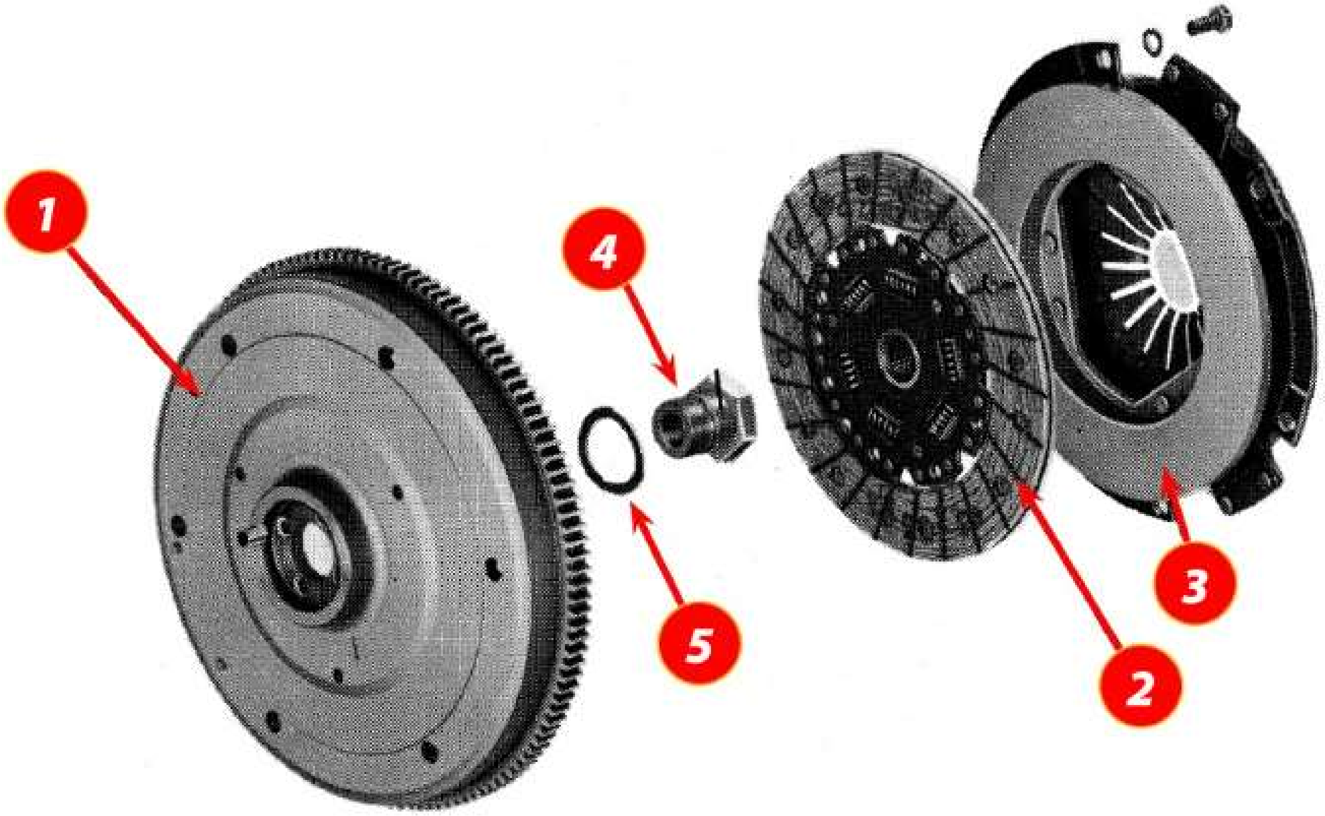


#16

Engine

Let's look at the real parts now. We show the flywheel (1) on the picture below, the pressure plate (3) is on the far right and in between is the clutch disc (2). The big bolt (4: flywheel bolt) and spring washer (5) are used to secure the flywheel to the crankshaft in the engine.

The pressure plate (3) is a big metal disc mounted in a lid with strong compression springs pressuring against the disc (2). These compression springs make sure that the clutch disc is in contact with the flywheel when the clutch pedal is released.

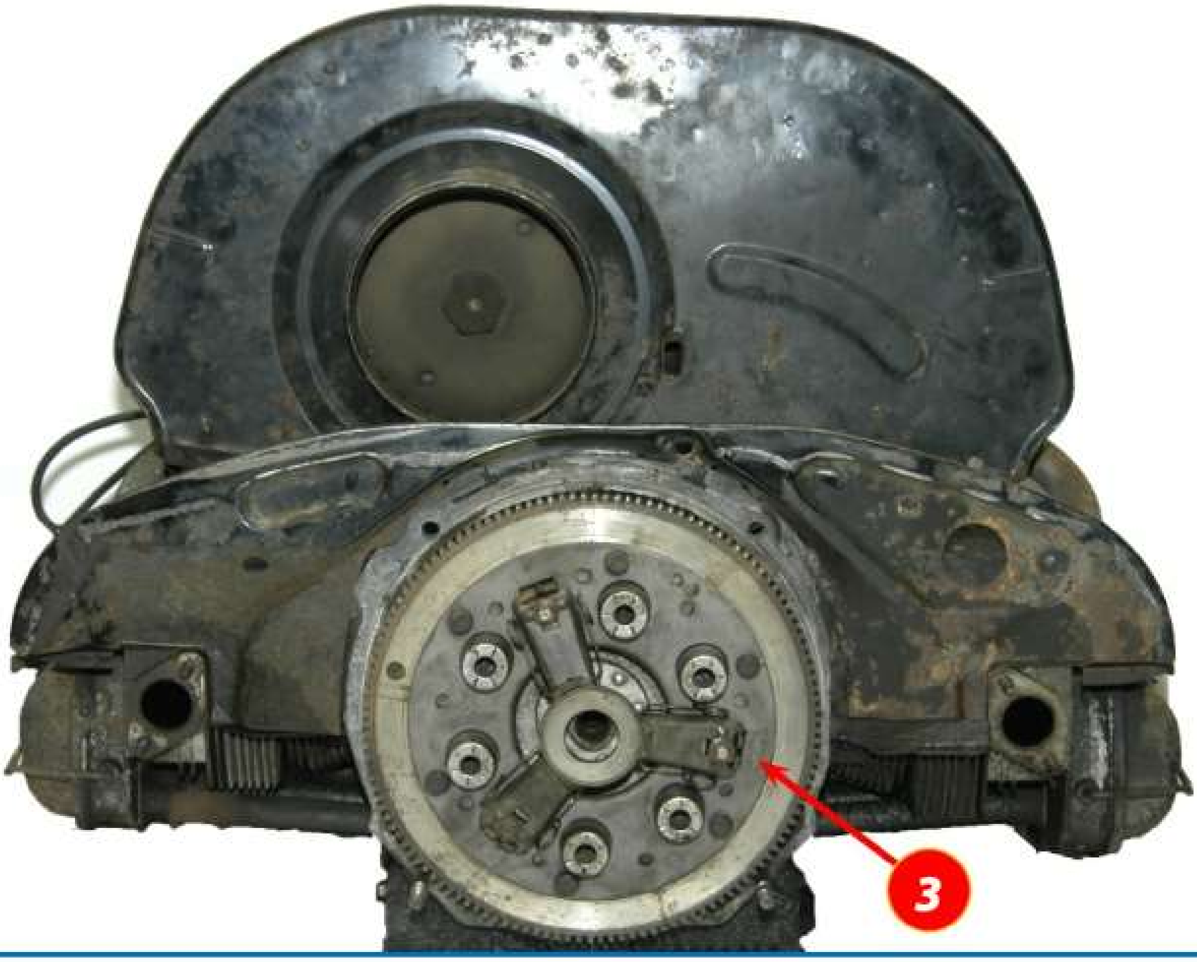


the clutch concept

The oldest type pressure plate is the one with coil springs. You will still see these types of pressure plates on old unrestored Volkswagens.

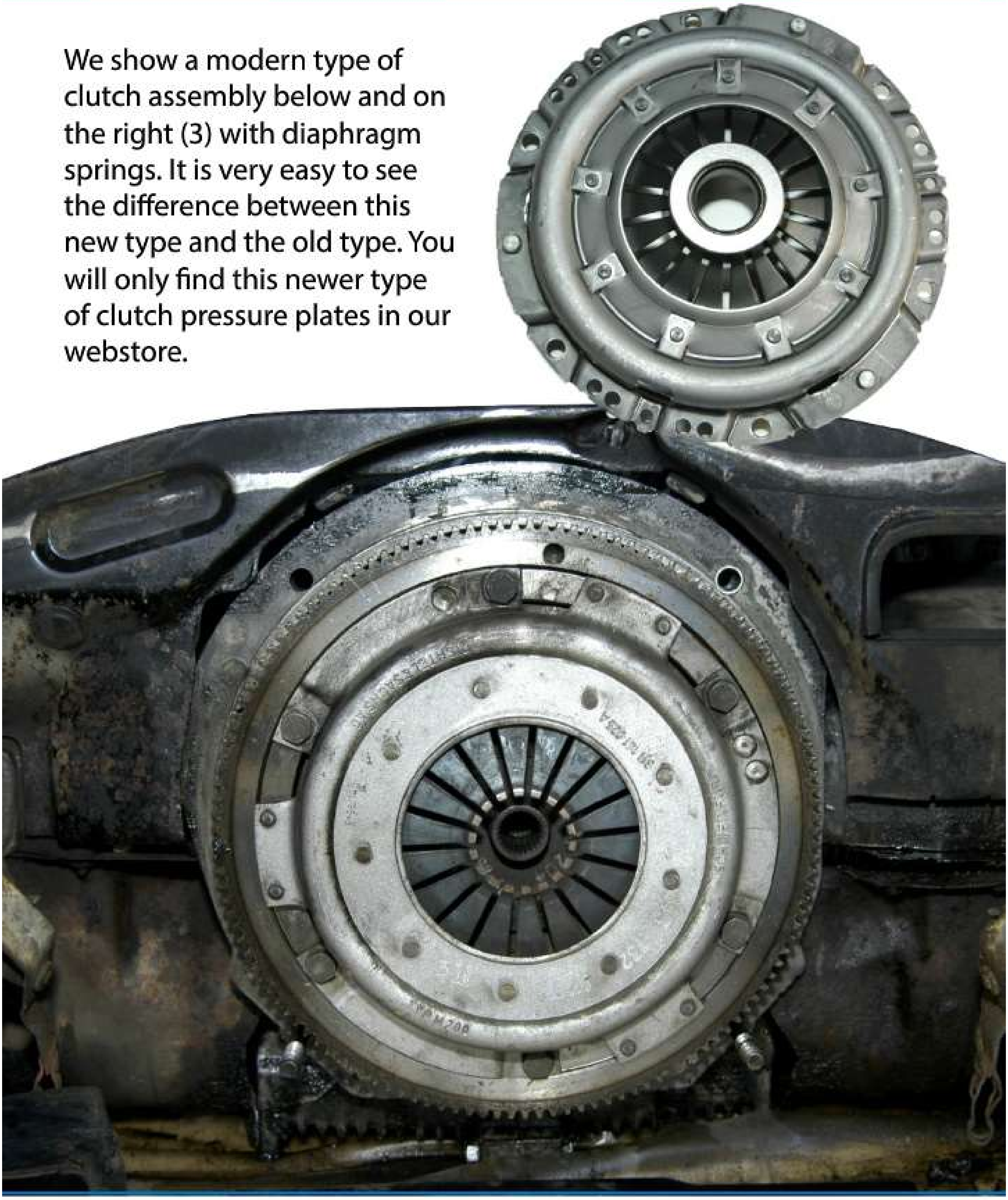
Modern pressure plates are using diaphragm springs. These clutch assemblies use less parts and are more reliable.

We show an old type of clutch assembly (3) on the picture below installed on an air-cooled boxer engine. A newer type with diaphragm springs is shown on the next page.



#16 Engine

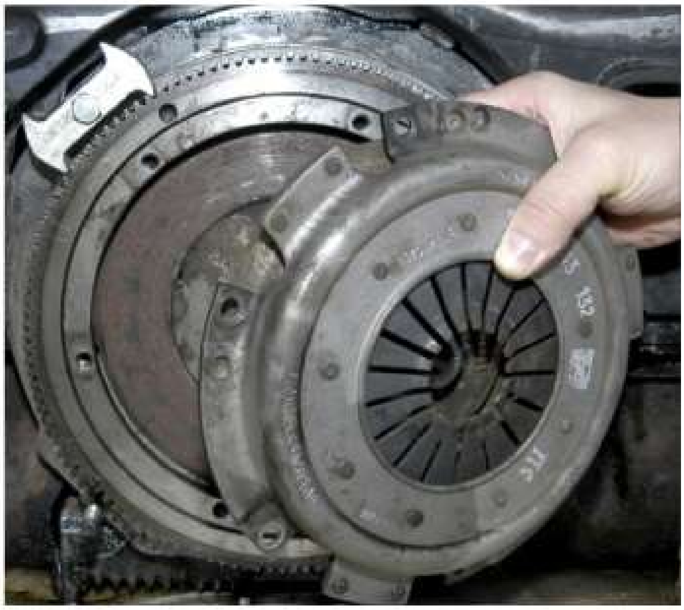
We show a modern type of clutch assembly below and on the right (3) with diaphragm springs. It is very easy to see the difference between this new type and the old type. You will only find this newer type of clutch pressure plates in our webstore.

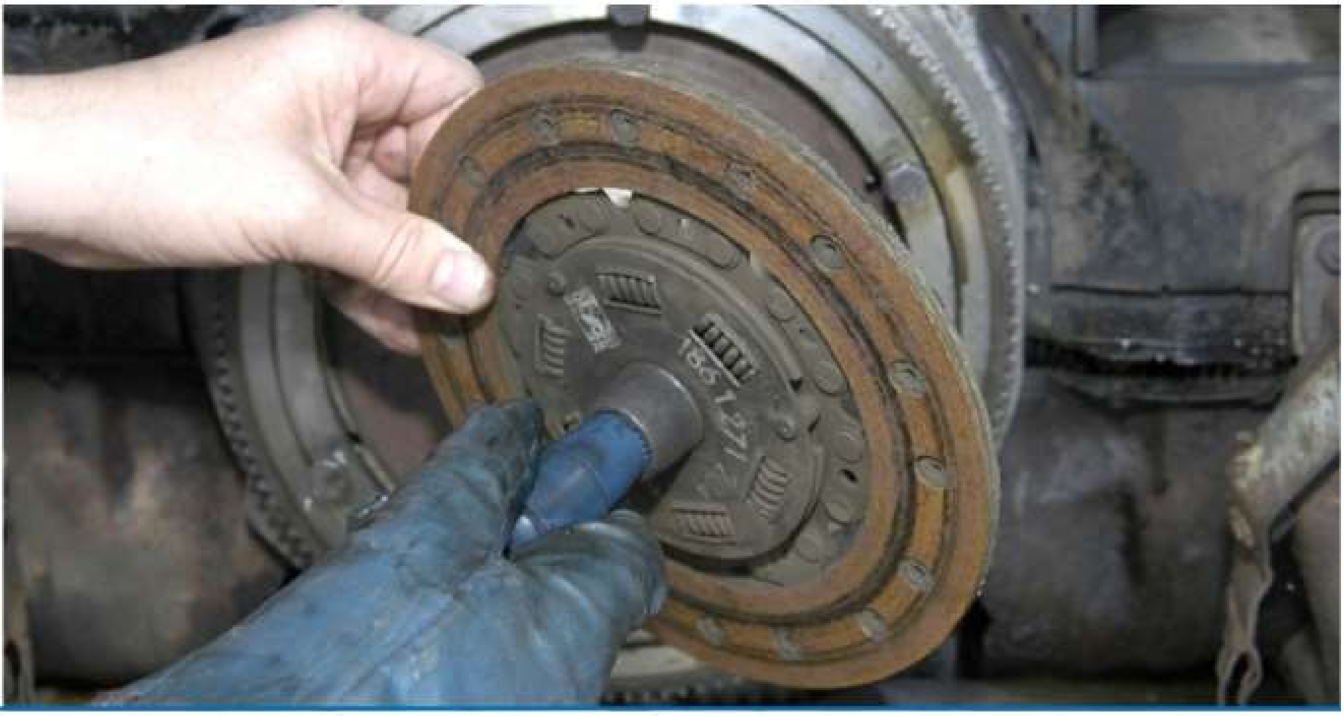


the clutch concept

This type of clutch with diaphragm springs is preferred nowadays because it offers a higher level of comfort for the driver. The issue with the old coil spring type clutch is that the pressure is equal from start to end. When you drive in modern traffic (read traffic jams) and you need to disengage the clutch regularly, your foot and your leg will start to hurt after a while. The diaphragm clutch once fully pressured will need less constant pressure to stay disengaged, which helps to the driver to have a greater driving experience.

We show on the pictures below how to dismantle the pressure plate. You can also see the clutch disc between the flywheel and pressure plate.

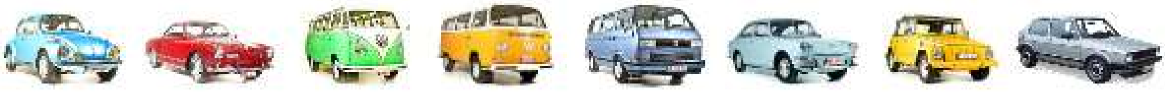




#16 Engine

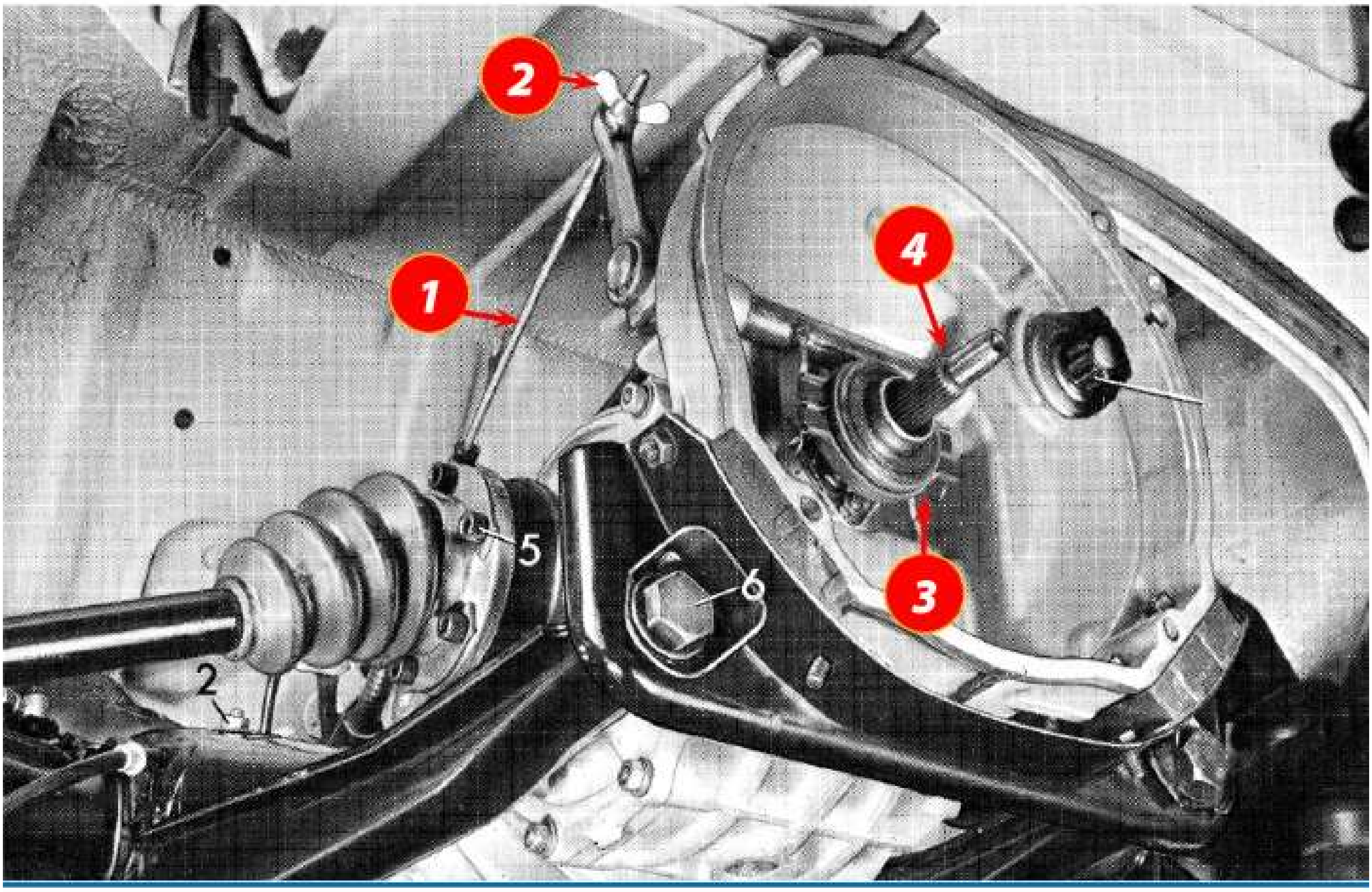
The clutch disc as shown on the picture above contains two friction plates, one on each side of the clutch disc, it is placed between the flywheel and the clutch pressure plate. The discs are composed from a series of slats secured with rivets. These slats are connected to the central hub using pressure springs. These springs are working just like your shock absorbers on your VW, they will absorb the vibrations caused by the engine.

Now you understand that operating the clutch pedal the wrong way can damage your clutch disc. If your clutch disc tends to slip too much and too often, the clutch disc will wear down rapidly. Check the clutch pedal free play on a regular basis and avoid unnecessary slipping of the clutch disc.



the clutch concept

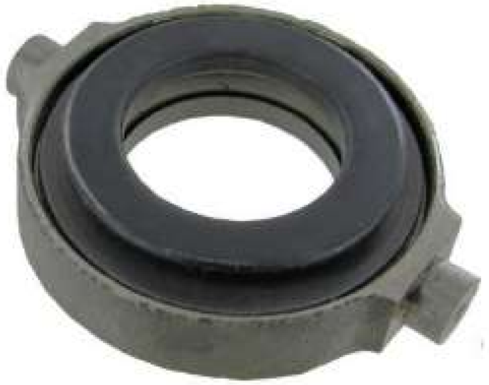
The clutch pedal operates the clutch cable (1), the clutch cable is connected to the clutch operating lever (2). When you push the clutch pedal the clutch operating lever will be pulled forward and it will rotate the operating lever shaft inside the gear box pushing the clutch release bearing (3) towards the clutch pressure plate. The clutch release bearing is installed onto the gear box shaft (4).

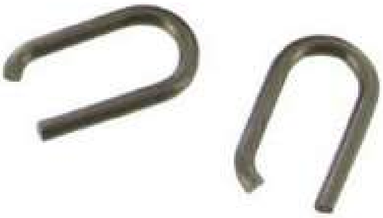


#16 Engine

Floating bearing

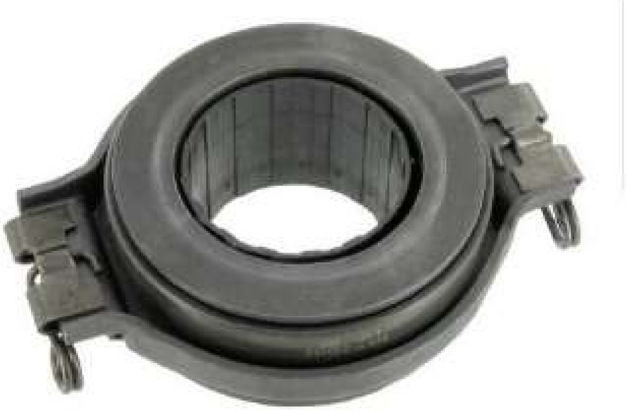
The older clutch types have this clutch release bearing that consists of a metal ring installed with clips.





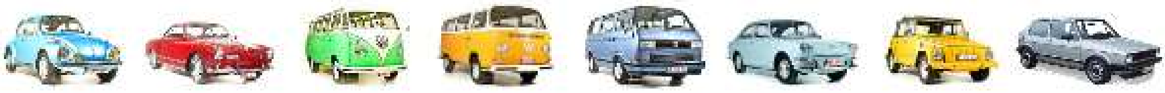
Fixed bearing

The younger VW types have this fixed bearing that slides over a clutch release bearing sleeve.



When you press the clutch pedal, the inner ring of the clutch release bearing will press against the clutch pressure plate. The outer ring stands still. This is possible because both rings on the release bearing are mounted on ball bearings.

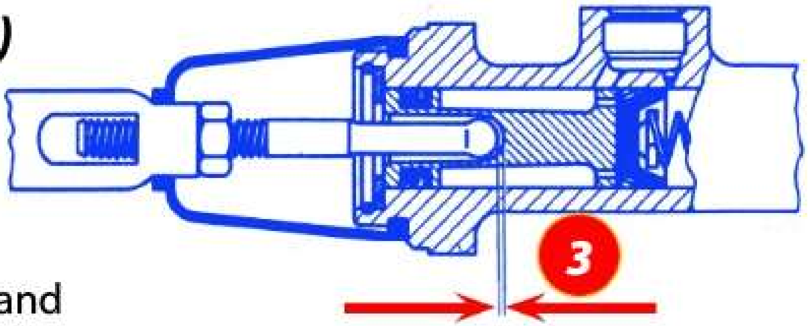
The clutch release bearing is prepared with special grease by the manufacturer, guaranteed for lifetime operations, you don't need to add additional grease when installing the clutch assembly.



Hydraulic clutch

Volkswagen introduced an hydraulic powered clutch system starting 1980, it was installed on the T25 Vanagon. Competing brands were much faster in using this modern technology. The master clutch cylinder (1) is installed behind the clutch pedal, it will build up pressure in the clutch hydraulic line. The pressurized hydraulic fluid will flow to the clutch slave cylinder (2) installed on top of the gear box. It is this slave cylinder that will operate the clutch operating lever.

Free play (hydraulic)



The free play is about 3 to 4 mm for this type of clutch system! You need to tweak your clutch pedal and the shaft in the cylinder so that there is about 0.5 mm play between the operating shaft and the cylinder piston (3), check the manual for your type of VW hydraulic system.

We will discuss how to dismantle and how to install and fine-tune your clutch assembly in one of our next issues.

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#17 Tip

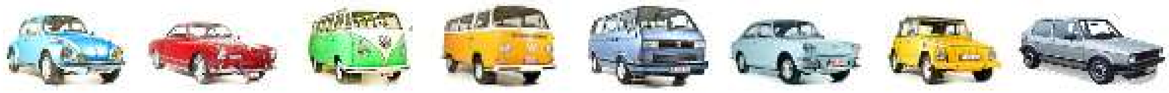
The Otto engine

What is the Top Dead Center (TDC) really? We need to talk about how a combustion engine works (also called the Otto engine) everything will become more understandable after this quick academic talk. I don't want to go too much into details, but explaining the basic principle of a four stroke-engine is the least we should do.

All the classic Volkswagens have a four-stroke engine based on the Otto four stroke cycle principle. The crankshaft will do two revolutions per cycle, and two strokes per revolution. So, the pistons will move twice towards the spark plug and twice towards the crankshaft, in total four-strokes, hence the name four-stroke engine. The spark plug will fire once during that four-stroke cycle, it will ignite the air-fuel mixture and generate the power to run the engine.

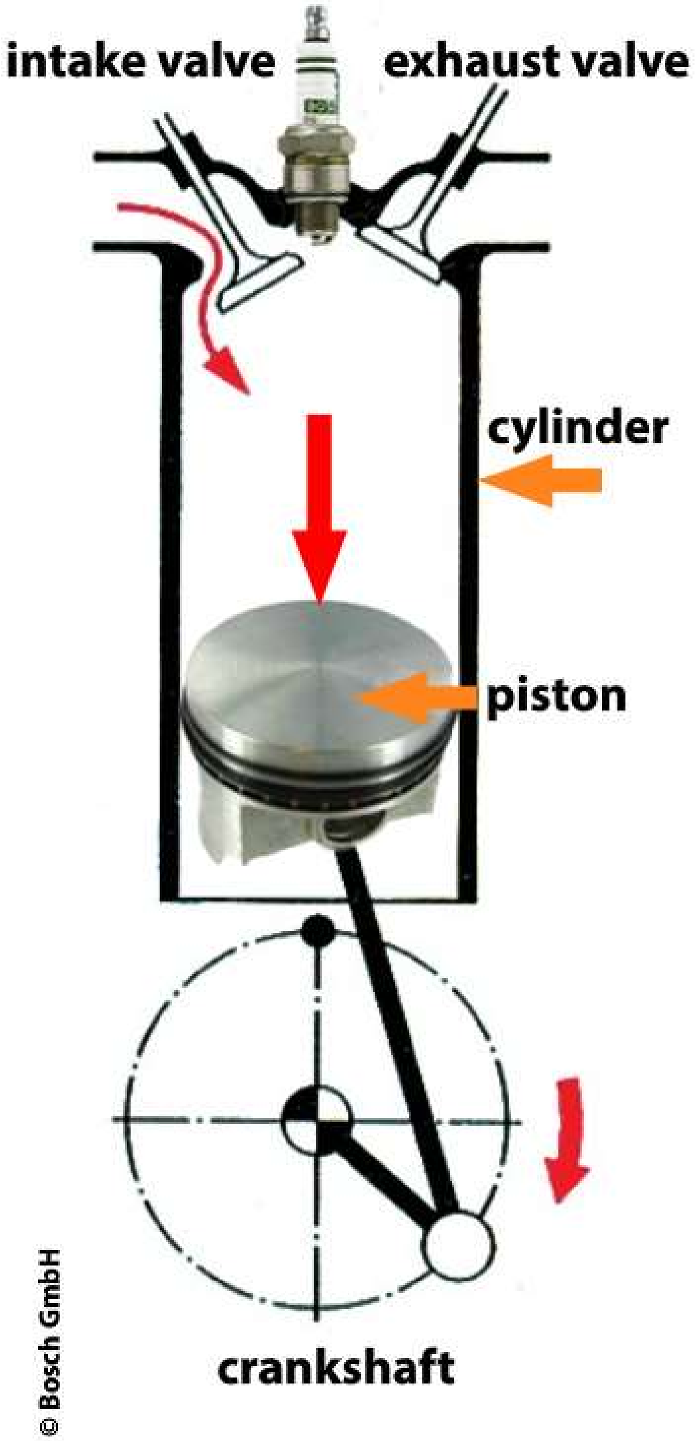
We show a conceptual drawing of the Otto engine principle on the next page. You see the crankshaft rotation at the bottom of the drawing, the crankshaft is connected to the piston in the cylinder. The spark plug is shown on top, left from the spark plug is the intake valve (or inlet valve) and on the right is the exhaust valve.

This drawing is a conceptual representation coming from a Bosch manual, it doesn't show exactly how a Volkswagen boxer engine looks like, but the principle is the same for all four-strokes Otto engines. So, it gives you a good idea how our VW air-cooled or water-cooled boxer engines work, or how an in-line engine such as the one in the VW Golf or T25 Vanagon works, or even how V-engines work.



finding the top dead center

1st stroke: intake



We show the first stroke on the drawing, the intake valve opens, the pistons moves towards the crankshaft, away from the spark plug, and sucks the air-fuel mixture coming from the carburetor (or fuel injector) into the cylinder. The valves are controlled by the camshaft and the push rods, we don't show them on this drawing to simplify. If you want to know more about this, read the article in edition 4 on page 42.

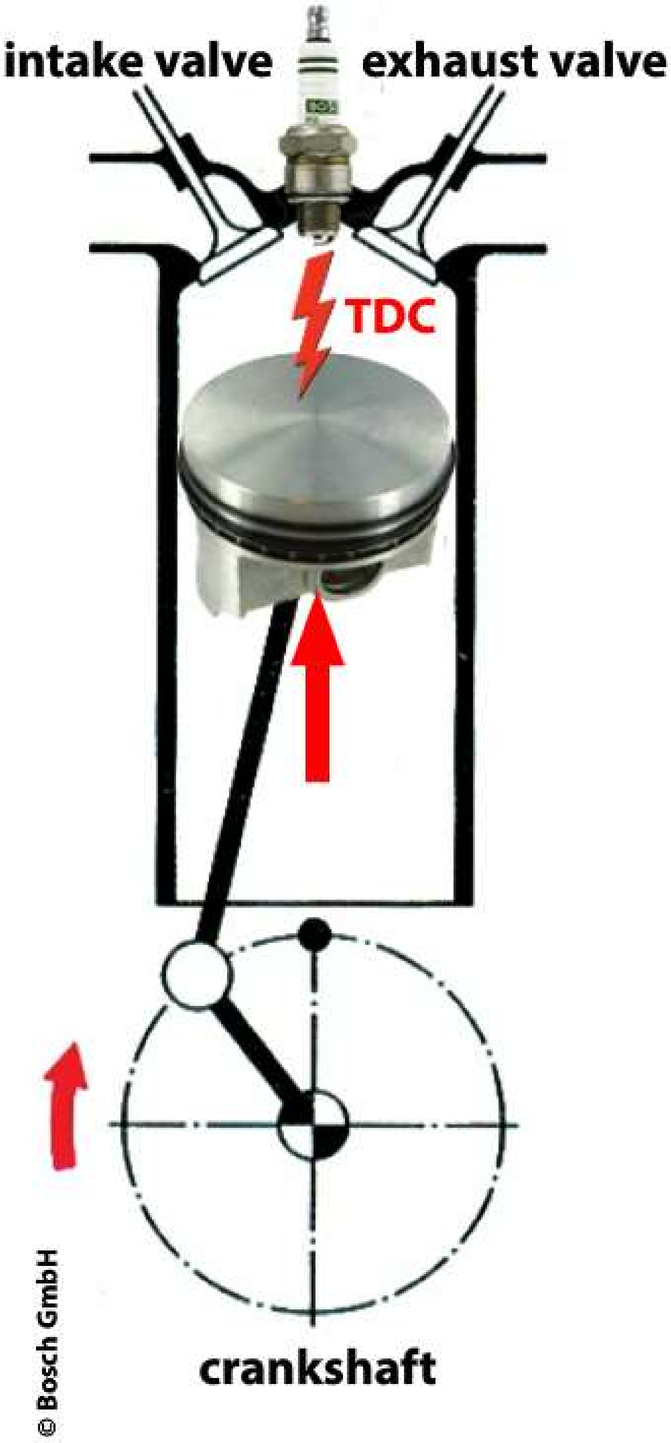
The intake valve is open during the 1st stroke of the four-stroke cycle, the exhaust valve is closed, the piston moves downward on the picture, towards the crankshaft. The air-fuel mixture fills the cylinder without igniting in this stage of the process.

#17 Tip

We show the 2nd stroke on the drawing, both valves are closed during this compression stroke, the piston moves towards the spark plug. The piston moves because the crankshaft forces the piston to move. The air-fuel mixture - a gas mixture created in the carburetor (or injector) by mixing air coming from the air filter and fuel coming from the fuel pump - is compressed by the moving piston. The piston rings make sure that the air-fuel mixture stays in the cylinder between the piston and the valves, no gas mixture should be able to escape at this stage of the process.

The piston will reach the top of the cylinder, this is called the **Top Dead Center (TDC)**, the ignition system will charge the high voltage spark plug cable with a high voltage, the spark plug generates a strong spark that ignites the compressed air-fuel mixture. The combustion of the gas mixture is started at this right moment.

2nd stroke: compression



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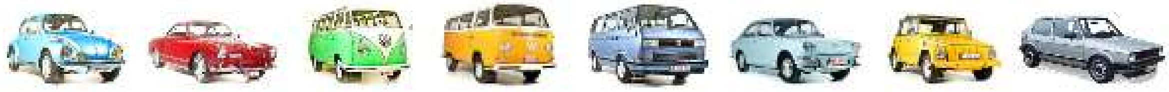
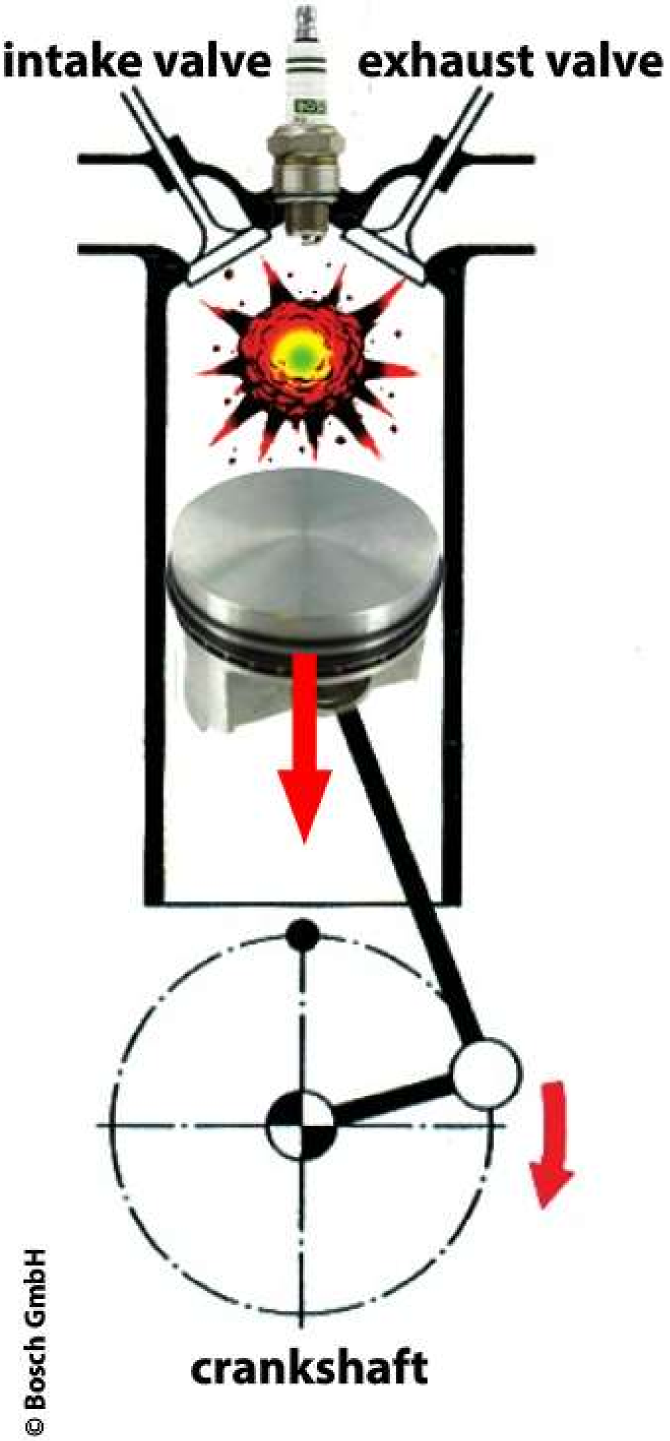


finding the top dead center

3rd stroke: power stroke



Both valves are still closed during the 3rd stroke, the piston moves back towards the crankshaft forced by the enormous expansion power that the air-fuel combustion (read explosion) has created. The piston generates a great force on the crankshaft, that is why we call this the power stroke. The air-fuel mixture is completely burned up at the end of this cycle, it has no reason to stay in the cylinder and rapid exhaust is necessary. And, this is exactly what will happen during the fourth stroke.

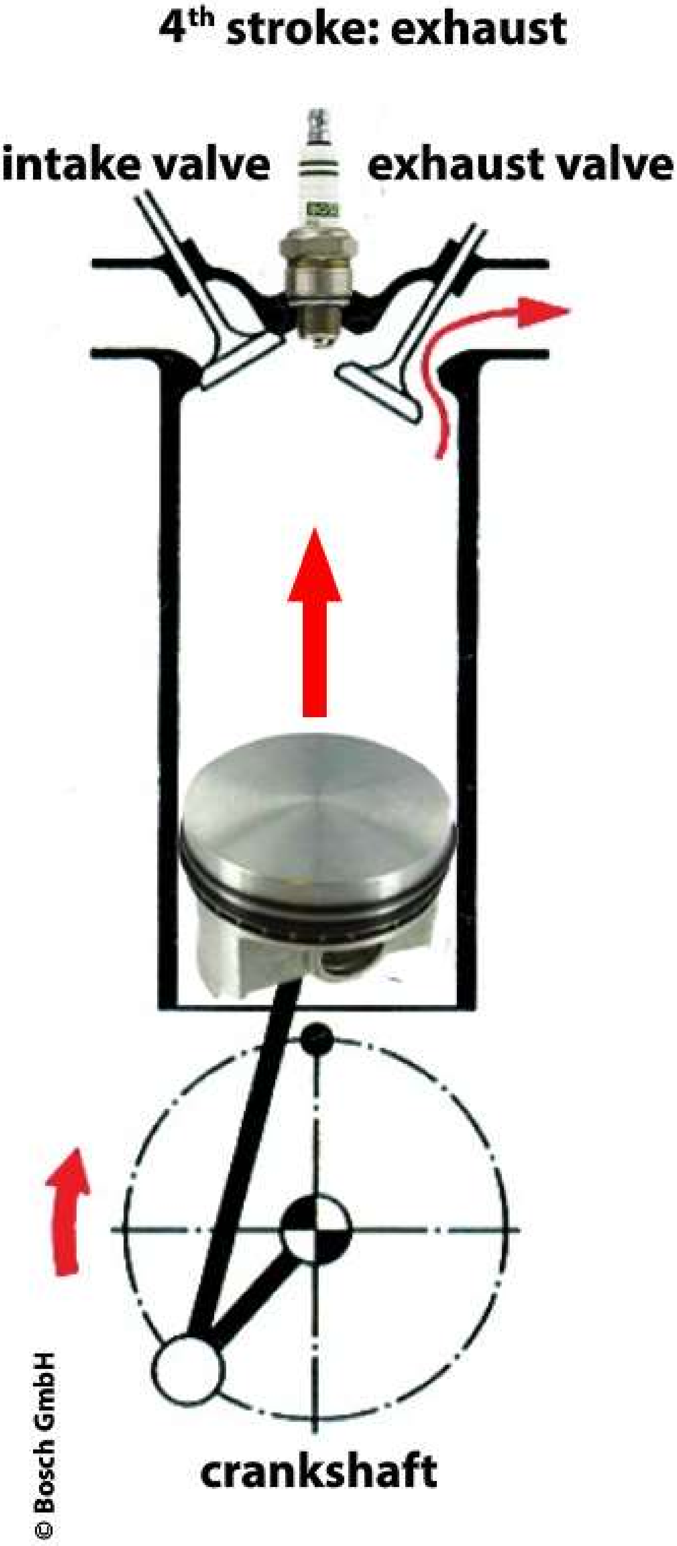
Both valves are closed during this 3rd stroke, it is of the utmost importance that both valves shutdown completely to avoid loss of power generated by the expanding mixture. You don't want part of the combustion power to disappear through the exhaust valve, that is what should happen during the 4th stroke. Combustion power escaping through the intake valve could damage your carburetor.

#17 Tip

The final and 4th stroke from the four-stroke cycle is the exhaust stroke. The exhaust valve opens and the piston moves towards the spark plug again, the piston moves because the crankshaft forces the piston to move. The burned up gas mixture from stroke 3 or also called the power stroke can escape now through the open exhaust valve to the exhaust tube.

It is critical that there is no combustion happening during this stroke. The intake valve should be firmly closed to make sure that the exhaust gas is not reaching the carburetor. The exhaust valve closes at the end of this stroke, the intake valve opens, we are back to the 1st stroke of the four-stroke cyles of our Otto engine.

Now that you have a better understanding on how the four-stroke combustion engine works, it is time to start explaining how to find the TDC.



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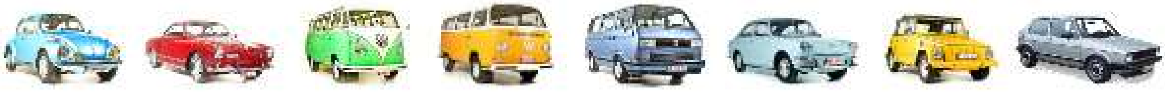


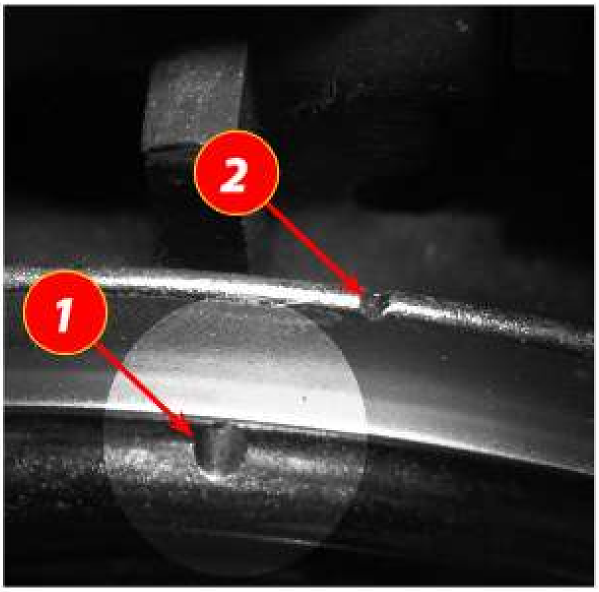
finding the top dead center

Top dead center (TDC)

So now we understand why the crankshaft will do two revolutions per cycle, and two strokes per revolution. The pistons moves twice towards the spark plug and twice towards the crankshaft, in total four-strokes.

The piston will reach the **TDC** during the 2nd stroke, the air-fuel mixture is compressed while both valves are completely closed. This exact moment when the piston reaches the top of the cylinder is called the **Top Dead Center (TDC)**. You will need to know when a cylinder has reached the TDC to set the valve clearance for instance, as we discussed in edition 5 on page 2, we explained how to find the TDC using the mark on the crankshaft pulley.

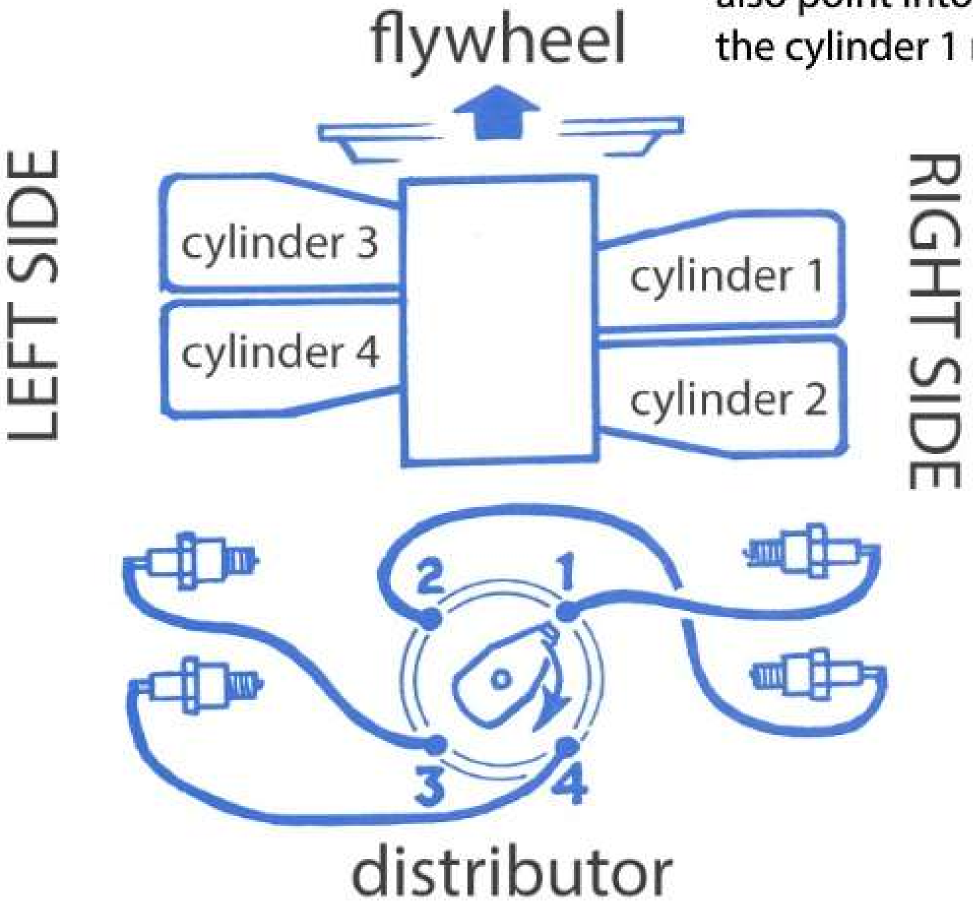
It is very easy find the TDC when your VW is completely original, the mark (notch) on the crankshaft pulley and the notch on the distributor will both help you to do just that. We have explained this procedure in edition 04. Don't confuse the notch for the TDC (1) on the crankshaft pulley with the other notch (2) on this same crankshaft pulley. The second notch is there to help you set the spark advance. If your VW is not that original anymore, finding the TDC can be a challenge.



#17 Tip

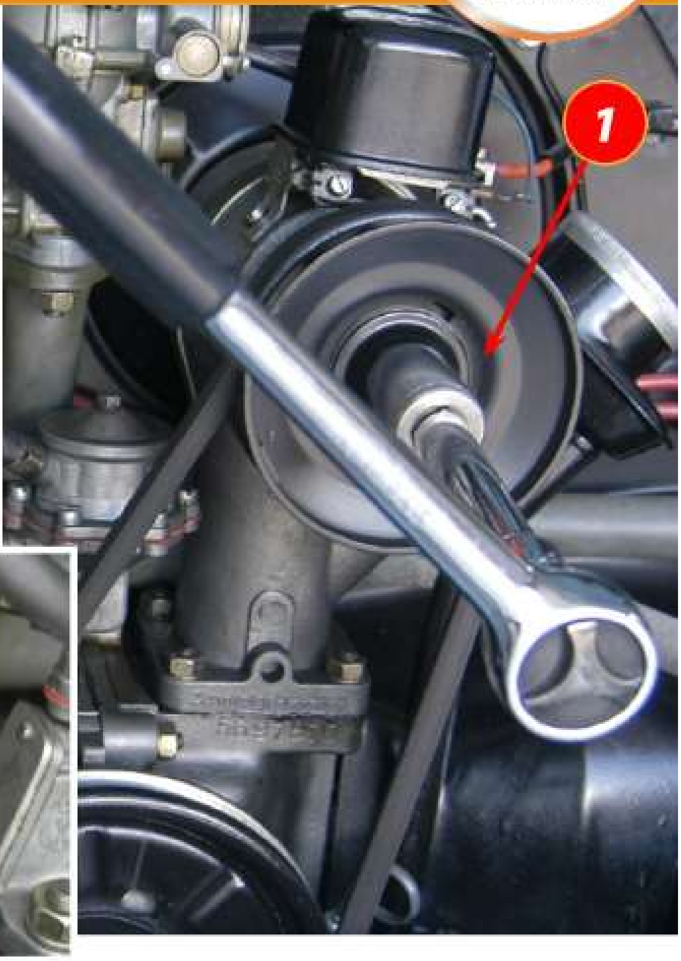
Now, let's be a little creative for a moment, just forget the notches on the crankshaft pulley and let's try to find the TDC for cylinder 1 the hard way?

Cylinder 1 is on the far right viewed from the back of your air-cooled Volkswagen as shown on the drawing below.

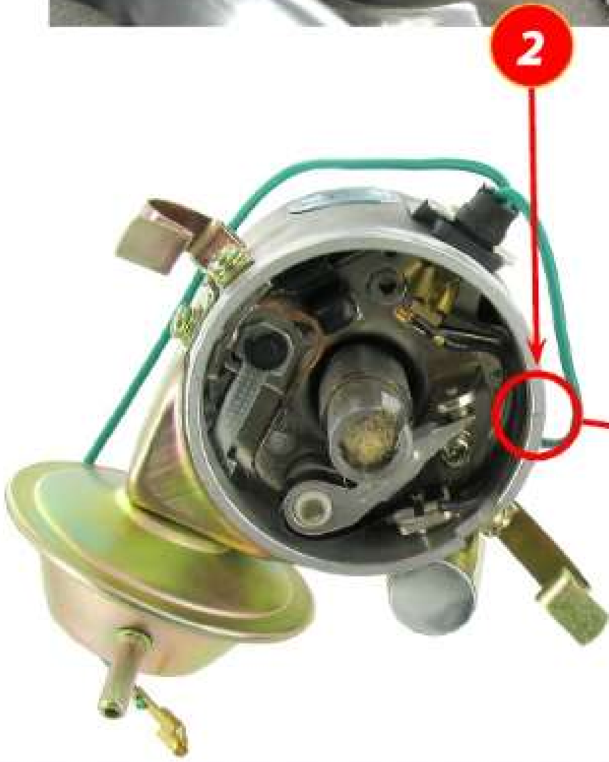


What we know from the introduction text is that the TDC is reached when the piston is as close as possible to the spark plug and when both valves (intake and exhaust valves) are closed. The spark plug will also fire to ignite the compressed air-fuel mixture (not exactly, but lets forget about the spark advance for a while) at the TDC. So, the rotor in the distributor should also point into the direction of the cylinder 1 notch. Let's take into account the piston position and the position of the rotor to find the TDC, forget about the notch in the crankshaft pulley.

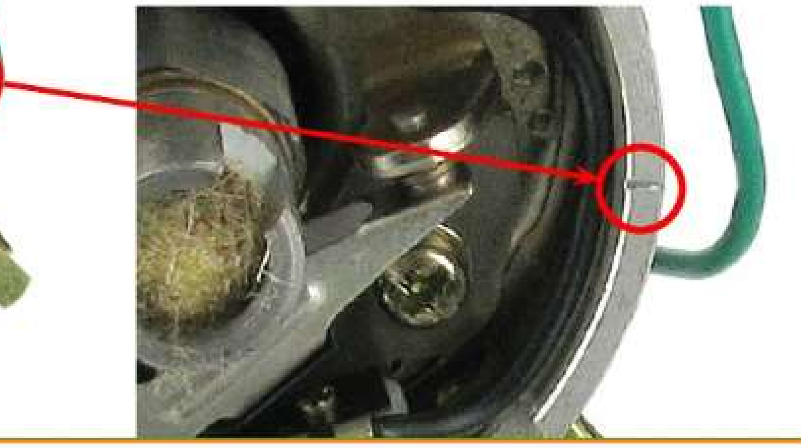
finding the top dead center



Rotate the pulley (1) until the rotor points towards the spark plug cable of cylinder 1, there should be a small notch visible as shown on the picture below (2). Having the rotor pointing towards this notch tells you that cylinder 1 is in its TDC.



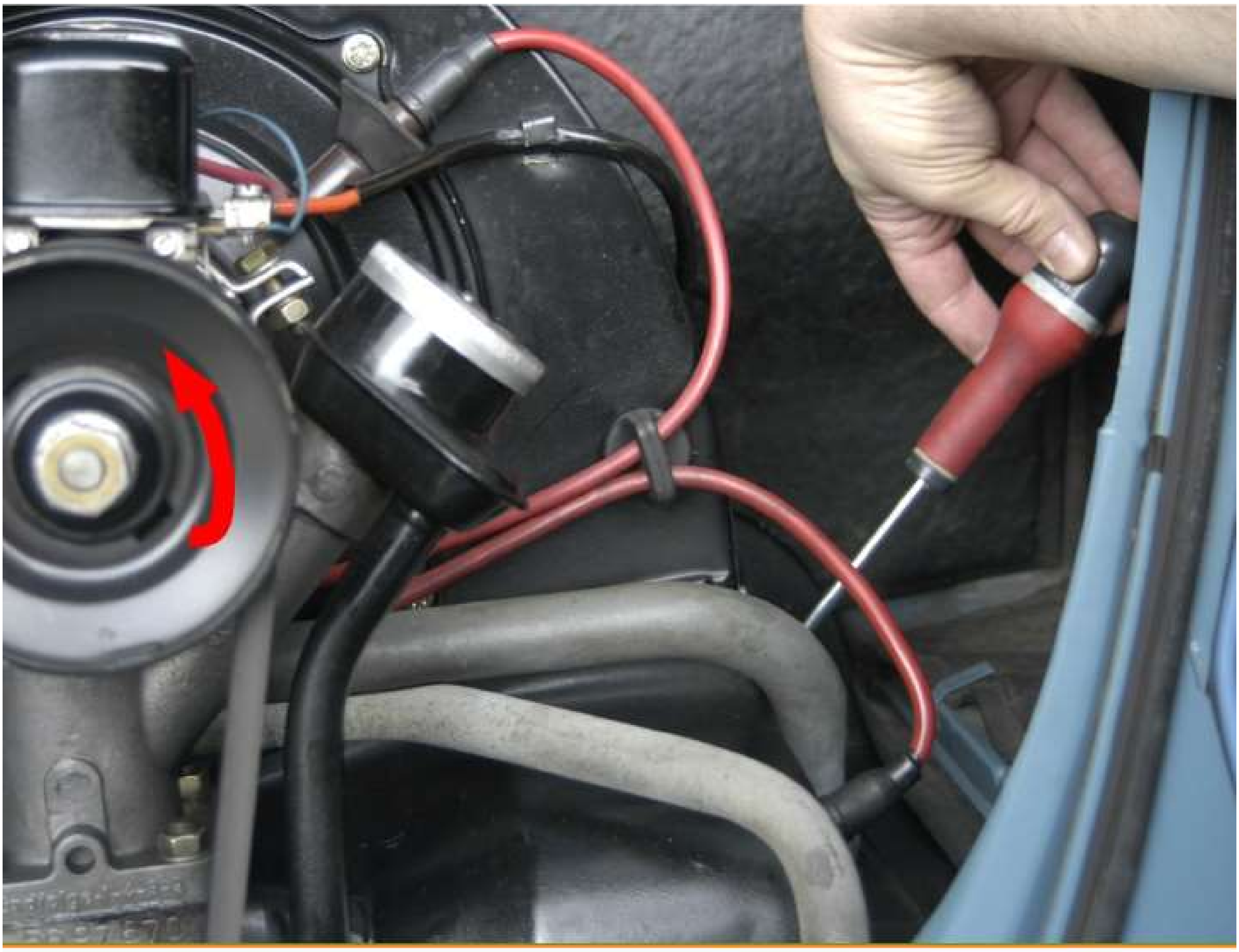
How the distributor is positioned on the pictures is not necessarily the position of your distributor, it will be different for each engine type.



#17 Tip

Remove the spark plug cable for cylinder 1, then remove the spark plug. Use a screw driver to find out what the position of the cylinder 1 piston is. Make sure nothing falls into the cylinder. It seems a little strange to do that at first, but there is nothing wrong with this procedure.

Let the screwdriver rest on top of the piston and rotate the pulley both left and right, you will feel the piston moving and you will see the screwdriver move up and down.



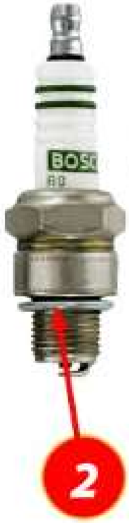
finding the top dead center

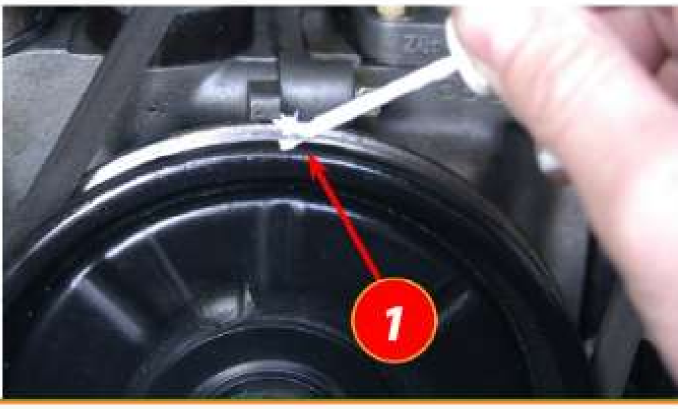
The TDC is reached when the screw driver reaches the highest position. You need to make sure that the rotor points into the direction of the small notch, as explained earlier. If both conditions are met, you have found the TDC for cylinder. You can set the valve clearance for cylinder 1 while the pulley is in this position, if you need to, we have explained how to set the valve clearance in edition 05 on page 2.

It is a good idea to add a mark on your crankshaft pulley, so you don't need to repeat this procedure to find the exact TDC for cylinder 1 again. Use paint that resists high temperatures. The mark on the pulley should be in line with the center of the crank as shown on the picture (1). If your paint mark for TDC of cylinder 1 is the same as the original notch in the crankshaft pulley, then you have double checked your TDC, if not, trust this simple procedure.

Finding the TDC for cylinder 2 goes the same way as cylinder 1. Rotate the pulley until the rotor in the distributor points towards the spark plug cable of cylinder 2. Remove the spark plug cable and the spark plug and follow the same procedure as for cylinder 1.

Just a small remark about reinstalling the old spark plugs. You should use this opportunity to inspect the health of your spark plugs and replace them if necessary. Don't forget that the metal ring (2) may only be compressed once. If the previous owner tighten the spark plug too hard, the metal ring could be damaged and not reusable. The torque value for the spark plug is between 30 and 35 Nm.





#18 Buying a VW

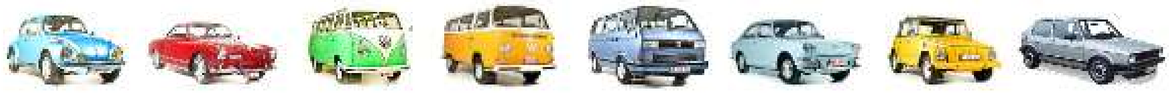
Engine performance

You are planning to buy a classic Volkswagen and you want to evaluate what the car is worth? You need to check the chassis and the body for corrosion first. Checking matching numbers, the interior and the accessories is important if authenticity is key for your purchase. Checking the state of mechanical parts is a little bit more difficult, you will need some experience for that. If you have the money to purchase a Vintage Convertible Beetle, Ghia or Split Screen, you won't worry too much if the engine needs an overhaul, as long as the numbers match (chassis number and engine number). Spending an additional few thousand euro's on an engine won't make the difference.

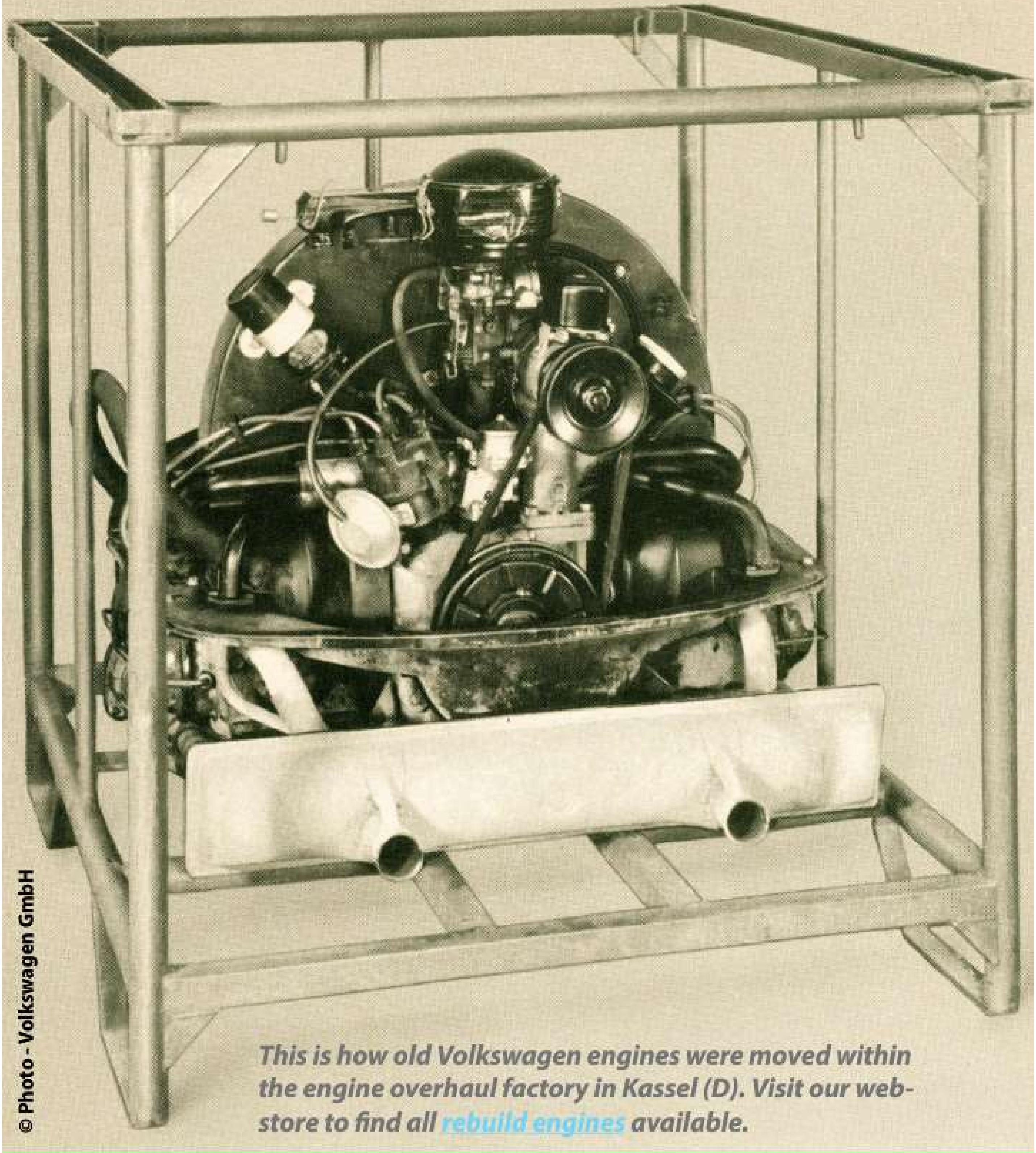
If you are purchasing a Beetle that is worth a few thousand euro's, I guess you don't want to spend another few thousand on the engine.

You can learn a lot about the mechanical health by taking a VW for a spin. You need some experience with that type of Volkswagen to know if it behaves correctly or not. If the engine doesn't run properly, it doesn't always mean that the engine is end of life. Maybe the ignition is faulty and the problem can be fixed with a simple tuning of the distributor or by replacing the coil, spark plugs or ignition wires. All these issues can be addressed without spending too much money.

How can you tell if it is time to overhaul the engine, how much wear is there under the engine lid? A good objective indication is the level of compression within the cylinders, how much compression the engine can still generate is key for the performance of the engine.



measuring the compression



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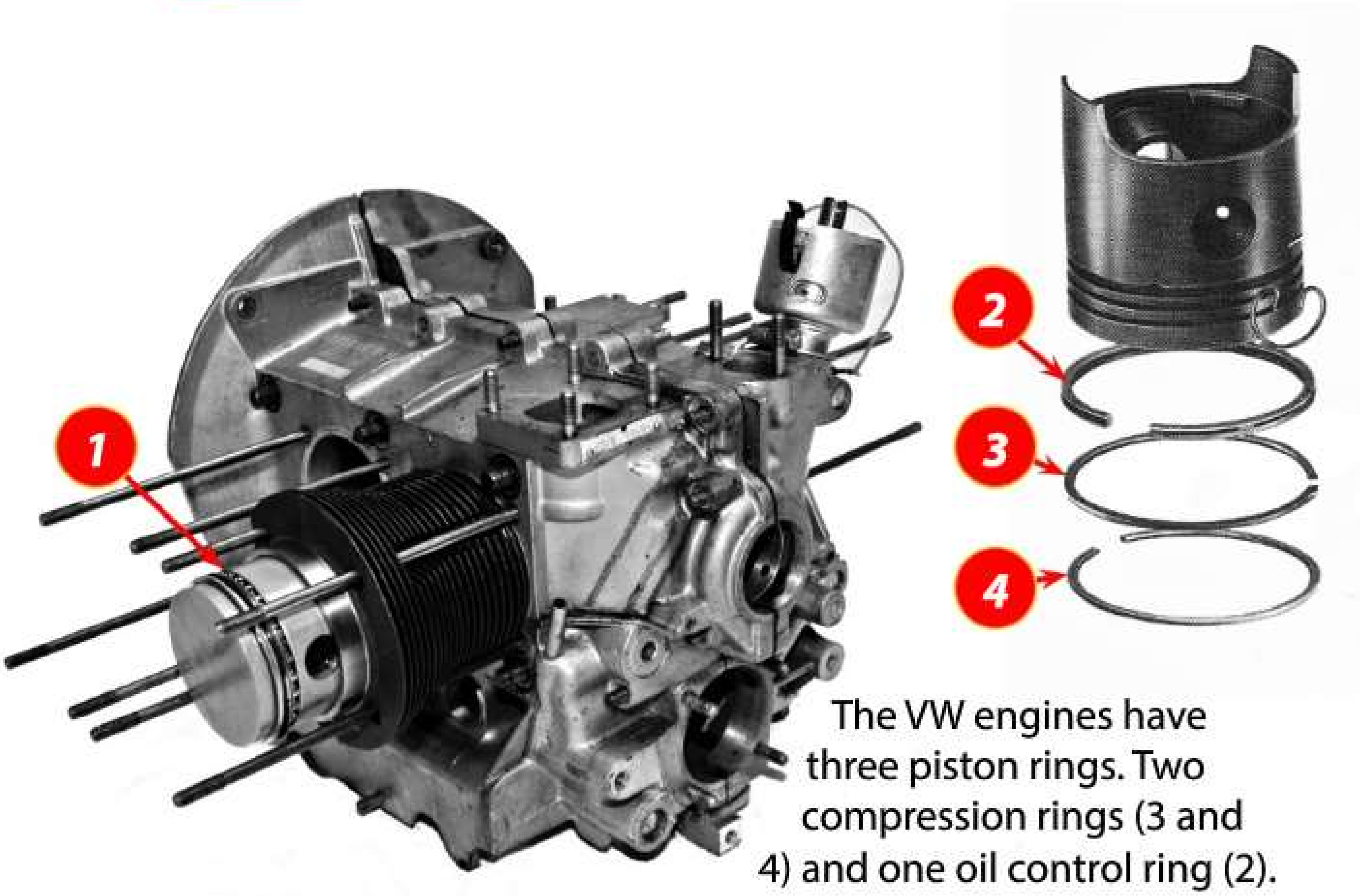
This is how old Volkswagen engines were moved within the engine overhaul factory in Kassel (D). Visit our webstore to find all rebuild engines available.

#18 Buying a VW

What is compression?

The cylinders are filled with air-fuel mixture during the intake stroke of the four-stroke cycle. This mixture is compressed by the pistons and ignited by the spark plugs. If you want to know more about this, read the article about finding the Top Dead Center on page 24.

The performance of the engine depends on how much the mixture is compressed and how well the spark plugs ignite this mixture. The compression depends on the adjustment of the valves but the piston rings (1) are the most important in the performance equation.



The VW engines have three piston rings. Two compression rings (3 and 4) and one oil control ring (2).

measuring the compression

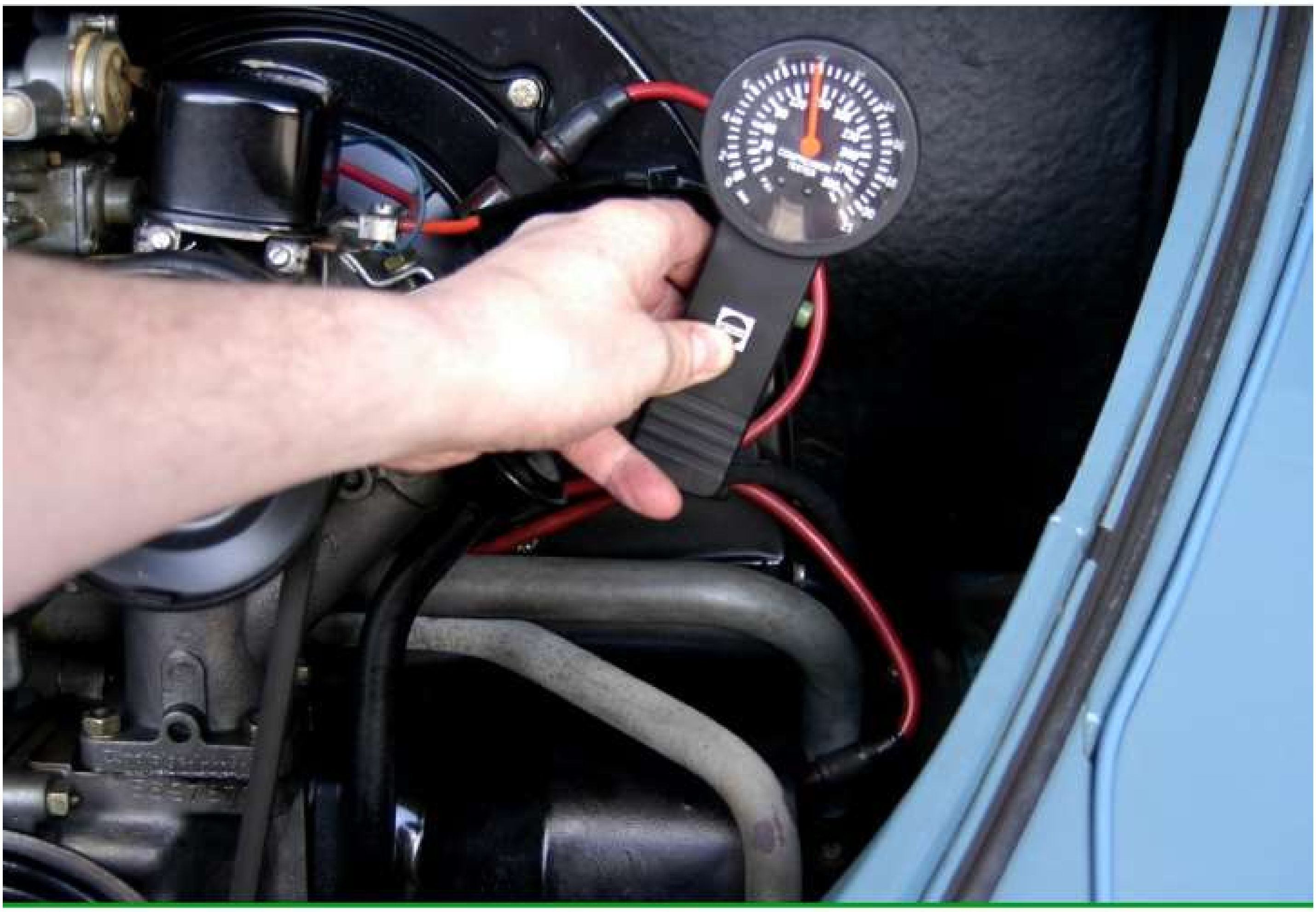
The compression will go down if the piston rings are in a bad shape. If the compression in the cylinders, or one of the cylinders, is dropping, the performance of the engine will drop. Worn out piston rings will not seal for 100%, engine oil will leak along the piston to the cylinder head and the valves. You should see "blue" exhaust fumes when that happens, the blue colored fumes is caused by the engine oil present in the air-fuel mixture in the cylinder(s).

We explained on page 26 what the compression stroke does.The compression stroke is compressing the air-fuel mixture in the cylinder. How much compression can be generated in the cylinder depends mainly on the quality of sealing of the piston rings.

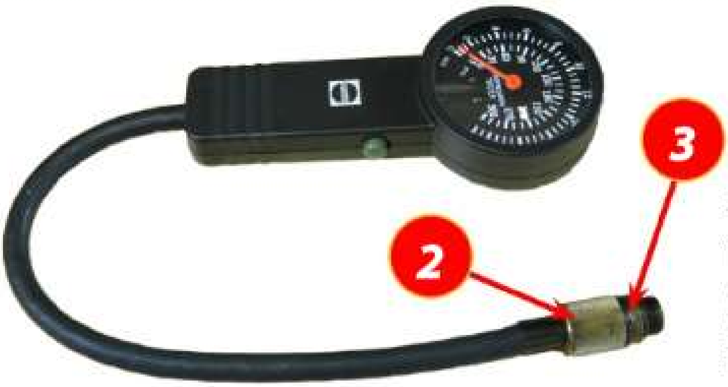
Let's start with elaborating on how to measure the compression of your Volkswagen engine. We show the compression gauge we used to write this article on the picture below.

Measuring compression

Our compression gauge has a small reset button (1), this button will reset the compression gauge to zero. The metric we use to measure the compression in the cylinders is "bar". Measure the compression at **operating temperature**, this means after you have taken the car for a short drive. You should measure a slightly higher compression if the engine is cold. You really want to measure the compression when the engine oil is warm and thin. You may measure the compression on a cold engine if you need to, the differences will not be that high really.

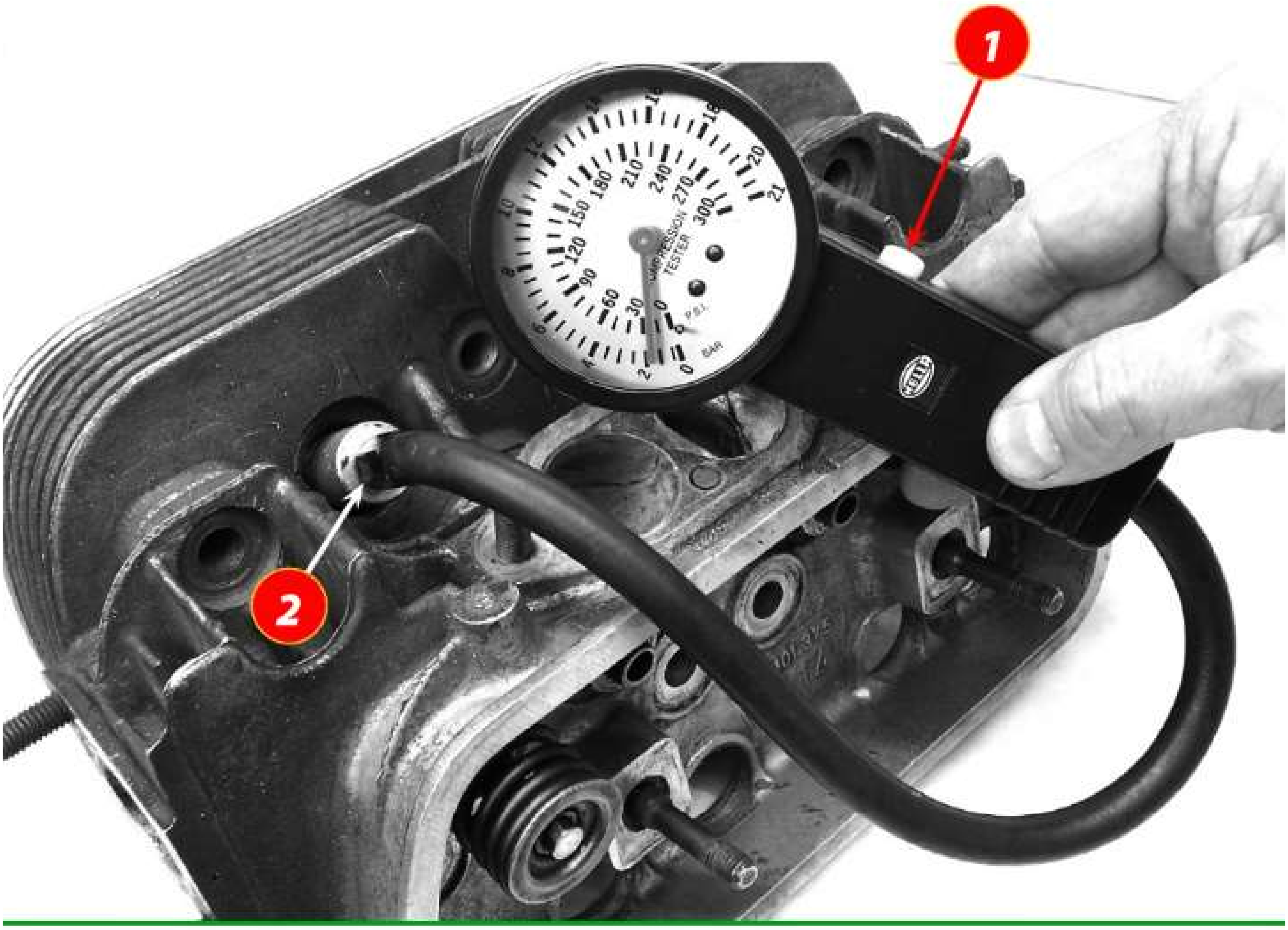


measuring the compression

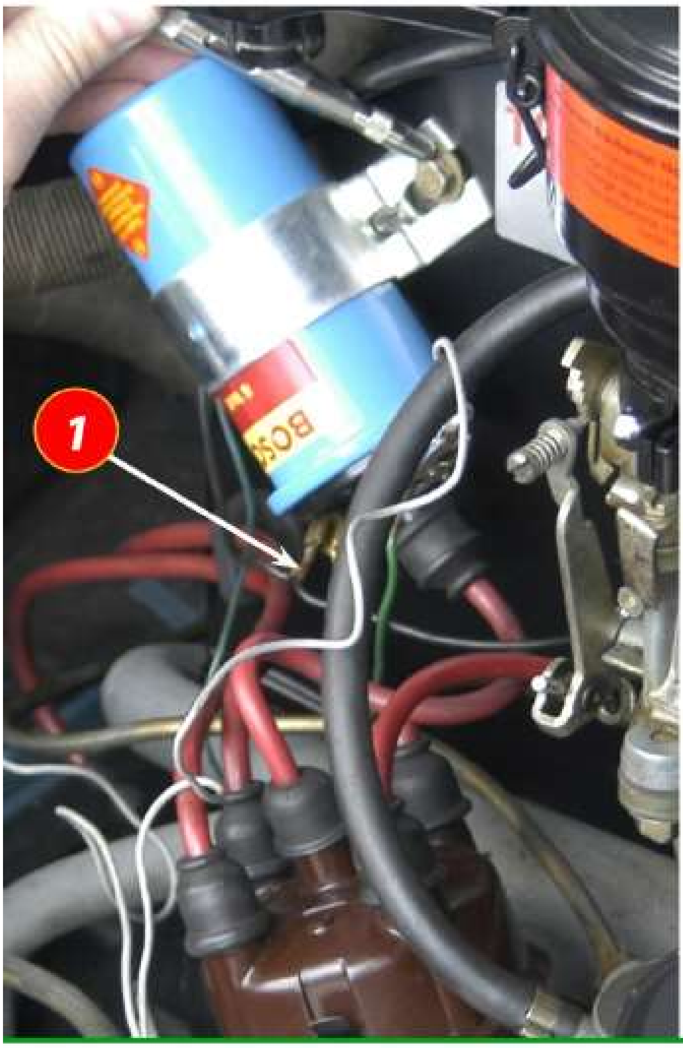


You want to measure the compression in all four cylinders before you make a decision to buy this Volkswagen.

So, remove all spark plugs on all four cylinders. Screw the thread (2) from the compression gauge in the cylinder 1 spark plug opening. Make sure the seal (3) on the compression gauge is well fitted. If not, this could influence the compression values you are measuring.



You need the engine to rotate to build up compression in the cylinders. You have removed all four spark plugs, so if you turn the ignition key the engine won't fire up. The distributor will still generate a high voltage, so maybe you want to remove the low voltage input cables (1) from the coil to avoid high voltage sparks under the engine lid.



Ask a friend to turn the ignition key. The engine won't start because there is no high voltage for the spark plugs. Your friend should push the throttle pedal all the way in during the measurement. Let the engine rotate about five times, so about five seconds. This should be enough to get a good measurement of the compression in cylinder 1.

Now you have the value of the compression in cylinder 1. Our test car had a value of 10 bar (picture on page 40). Repeat this procedure for cylinder 2, 3 and 4. The compression of each cylinder will tell you if the engine is still healthy. The compression value is important, but the difference between cylinders is even more important. You shouldn't have too much difference between cylinders, otherwise your engine needs overhaul.

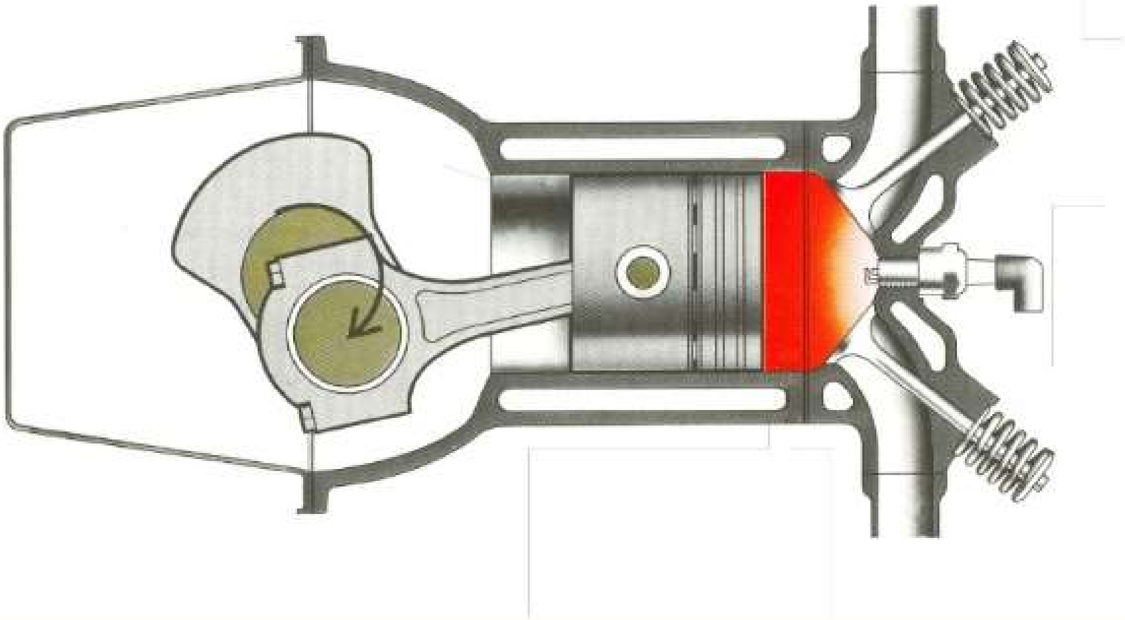
Watch out, an engine that has recently been overhauled can show low compression values because the piston rings didn't have the time to adjust!

Compression and compression ratio

What we have measured in this article is the compression in the cylinder. Don't confuse this with the compression ratio, a value that you will see a lot on engine technical data sheets.

We have measured the compression using a compression gauge. This is the maximum pressure in bar that is generated in a cylinder during the compression stroke, when the air-fuel mixture is being compressed just before the combustion.

The compression ratio measures how much the air-fuel mixture is being compressed during the compression stroke. This is the difference between the volume of the mixture flowing into the cylinder during the intake stroke and the volume of the mixture after it has been compressed at the end of the compression stroke. The compression ratio is always lower than the compression we measured here. A VW engine with a compression ratio of 7,5:1 will have a compression of about 10 bar.



#18

Buying a VW

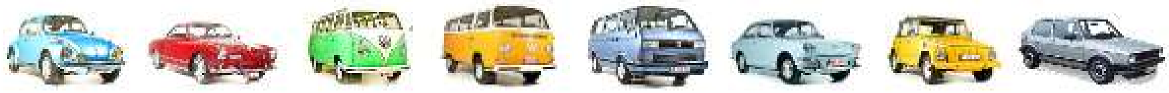
How much compression should your engine generate? The wear limit is the lowest compression value you should measure. This is an important value, but what is even more important is the difference in compression value between cylinders. You should not measure more than 1 to 1,5 bar of difference between cylinders. You can drive a car with a 2 bar difference between cylinders, but you will feel that when the engine is idling. The engine will need to be overhauled if you measure a compression value below the wear limit.

We show the compression value for some air-cooled Type 1 engines in the table below. Check the original technical data for your engine or ask your engine manufacturer.

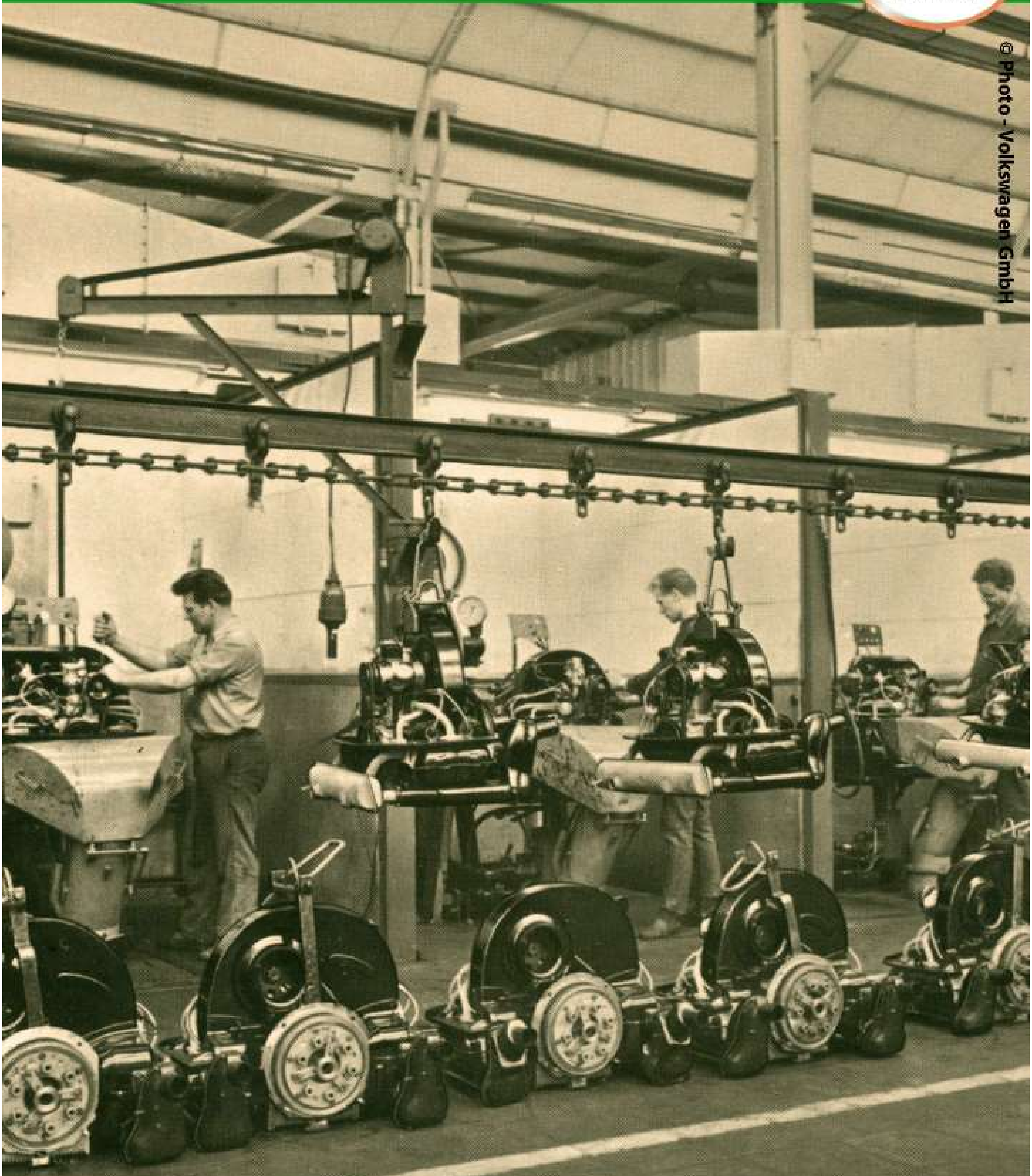
Is this compression measurement always correct? For sure not. If you measure a very low compression in one of the cylinders, it is possible that the valve clearance is not set properly. The compression values can also be influenced by a starter motor that is not rotating fast enough. So, use this compression test to measure differences in cylinder compression, don't try to measure absolute values or don't start a discussion based on absolute values. A leak-down test could give you more information, but more about that next time.

On the right page, an archive picture from a flyer that was created to promote the new Volkswagen factory in Kassel. You see these overhauled boxer engines almost ready to be transported to the local VW dealer. Check the Paruzzi webstore to view all rebuild engines available.

Engine volume	Engine Type	NEW	Wear limit
1200 cc	**Type 1**	**7-9 bar**	**6 bar**
1300 cc	**Type 1**	**7,5-9,5 bar**	**6,5 bar**
1600 cc	**Type 1**	**8-10 bar**	**7 bar**



measuring the compression



© Photo - Volkswagen GmbH

Koni shock absorber for the T2a

Paruzzi manufactures the original shock absorbers for the T2a Bus in cooperation with the original equipment manufacturer KONI. These shock absorbers are adjustable and guaranteed 100% equivalent to the original product.

VW Beetle, Karmann Ghia, type 3, VW Bus including T25/T3